SCIENCE TEACHING

GUIDELINES FOR EDUCATIONAL FUNCTIONARIES OF STATES

(Upper Primary and Secondary Stages)

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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FOREWORD

The National Policy on Education (NPE) – 1986 envisages a vital role for science education in developing well defined abilities in the cognitive, affective and psychomotor domains in children. They should be able to understand, interpret and deal with the various things and phenomena around them in a more scientific way. To achieve the desired goals, the science curriculum at all stages of school education has been redesigned in the light of the new developments in science and technology and the new needs to understand it. Needless to say, there have been tremendous achievements in our country in the field of education, however, there is still a need to evolve an effective strategy for implementing the science teaching programme to achieve the objectives stated in the NPE 1986 keeping in view our past experiences, present needs and future expectations.

The present volume has been developed in order to provide guidelines to State-level education functionaries working in different areas of the science teaching programme. It is expected that these guidelines will help the education functionaries in the States in implementing the science teaching programme effectively and as visualized in the NPE 1986.

The initial planning for the development of this material was done by a group consisting of Professor P.D. Shukla, Dr. Brahm Prakash and Dr. K.B. Gupta of the Department of Education in Science and Mathematics, NCERT. The academic needs of the States for implementing the science education programme were identified in a meeting with representatives of various States Education Departments. Keeping the needs of the States in view, the members of the group developed the first draft of guidelines in some selected areas of science education. The material was further developed in a workshop held in the Physics Department of the Osmania University, Hyderabad. The material was initially edited by the group members. It was then reviewed by Dr. R. Govinda, Senior Fellow, National Institute of Educational Planning and Administration, New Delhi. Finally the manuscript was edited by Dr. Brahm Prakash.

I thank Professor K. Rama Reddy of the Physics Department, Osmania University, Hyderabad for providing facilities to hold the workshop, and Dr. R. Govinda [illegible] and providing useful suggestions. I also thank the participating [illegible] for their valuable and significant contribution in the development [illegible] Ganguly, Head, Department [illegible] and active guidance in the development [illegible] Shukla, Dr. Brahm Prakash and [illegible] in developing this material. I especially appreciate the efforts of Dr Brahm Prakash for coordinating this programme and working relentlessly in the development of this material

Suggestions for the improvement of this material will be most welcome

P.L. MALHOTRA
Director
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Research & Training

6 November 1989
New Delhi

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GANDHIJI'S TALISMAN

"I will give you a talisman. Whenever you are in doubt or when the self becomes too much with you, apply the following test:

Recall the face of the poorest and the weakest man whom you may have seen, and ask yourself if the step you contemplate is going to be of any use to him. Will he gain [illegible]

CHAPTER 1

The Teaching of Science

A New Perspective

In India, there has been a remarkable change during the last [illegible] years in the perception of science education. [illegible] has played a vital role in every sphere of human development [illegible] a great deal of thought and [illegible] [illegible] [illegible] of today.

[illegible] changing [illegible] school [illegible] technology [illegible]

[illegible]

The important recommendations of the National Policy on Education [illegible] regarding science education [illegible]

1. [illegible] creativity [illegible]
2. [illegible] agriculture, industry and other aspects [illegible]

extend science education to the vast numbers who have remained outside the pale of formal education.

3. Children with special talent or aptitude should be provided opportunities to proceed at a faster pace, by making good quality education available to them irrespective of their capacity to pay for it
4. The availability of books at low prices is indispensable for people's education Efforts should be made to secure easy accessibility to books for all segments of the population Measures will be taken to promote the quality of books and to develop the reading habit and encourage creative writing.
5. Educational technology should be employed in the spread of useful information, the training and retraining of teachers to improve quality - both in the formal and the non-formal sectors.
6. The generation of relevant and culturally compatible educational programmes should form an important component of educational technology

1.2 Objectives of Science Teaching

1.2.1 The Upper Primary Stage

The objective of teaching science at the Upper Primary Stage are to

1. Consolidate and strengthen the abilities acquired at the Lower Primary Stage
2. Help the pupils understand and appreciate the nature of scientific knowledge that.
   - (i) it is replicable
   - (ii) it is based on observation
   - (iii) it is tentative
   - (iv) it is empirical
   - (v) it is holistic.
3. Emphasise the relevance of scientific knowledge and of the method of science in daily life
4. Create an environment conducive to greater reliance on the use of principles and practices of science
5. Acquaint the pupils with the different natural phenomena
6. Develop an understanding of scientific language (symbols and formulae), knowledge and skills for designing simple experiments
7. Emphasise those principles, concepts, laws and theories of science that are relevant for interacting with the environment
8. Emphasise the unity of processes in the different disciplines of science
9. Develop the scientific attitude, such as open- mindedness, intellectual honesty, the courage to question, and respect for human dignity
10. Emphasise the steps involved in proper decision-making based on the scientific method

11 Use science as a means of developing proper social and moral values in the pupils

1.2.2 The Secondary Stage

The objectives of teaching science at the Secondary Level are to:

1. Consolidate and strengthen the abilities acquired at the Upper Primary Stage
2. Acquire an understanding of scientific concepts, principles and laws
3. Develop instrumental, communicational and problem-solving skills
4. Develop the scientific temper and the scientific attitude, such as open mindedness, intellectual honesty, the courage to question, and respect for human dignity
5. Cultivate social, ethical, moral and aesthetic values, which exalt and refine the life of the individual and the society
6. Appreciate the contributions of scientists and develop sensitivity to possible uses of science, and concern for a clean environment and the preservation of the ecosystem.

1.3 The New Science Curriculum

In the new science curriculum, the content has been organised on the basis of two considerations, namely, the contemporary developments in science and the learning ability of the child The topics are presented sequentially and hierarchically on the basis of complexity, from the concrete to the abstract The learning ability of the child progresses with his mental development As the child progresses from the pre-primary to the primary stage, his mental development progresses from the pre-operational stage to the concrete operational stage During the latter part of the Upper Primary stage, the child gradually moves on to the formal operational stage.

The new curriculum has been designed in consonance with the levels of mental development of the child It would provide proper inputs and more secure connections for the transition from the pre-operational to the concrete and from the concrete to the formal operational level of mental development The formal-level concepts should provide experiences in terms of examples, analogies and activities so as to make them easily understandable

1.4 The Structure of the New Science Curriculum

Science for all is one of the most important recommendations of the NPE-1986 regarding science education. At the Upper Primary stage, the curriculum organisation should follow an integrated approach In our environment itself, all of us experience the laws of nature — not as physicists, chemists or biologists, but simply as human beings. Science is, therefore, one integrated whole and has always bean so. The integrated science curriculum reflects this unity of science

Up to the Upper Primary stage, more stress is laid on developing the concepts in a qualitative manner without any emphasis on quantification. From the secondary stage onward, the learners should develop the ability of quantifying of ideas and precision in measurement. This requires the introduction of rigorous laboratory work, projects, activities in science, etc

1. The Transaction of the New Science Curriculum

The NPE-1986 has emphasized the child centered and activity based learning approach to the transaction of the curriculum which requires greater participation of the pupils in the teaching learning process. Thus there has been a remarkable departure from the present practice of teaching in which the pupils remain passive listeners. The teacher should act as a facilitator of the educational process with the child at the centre of the teaching learning process. He/she should help the pupils in collecting information, its verification, and in other processes such as drawing inferences and conclusions.

1.5.1 Individualizing Science Instruction

There are enormous differences in background knowledge, intelligence, [illegible] motivation, [illegible], perceptions and aptitudes, among pupils in the main stream classroom. The mass education model [illegible] of the past are not suitable for providing a means by which every pupil can progress at his maximum rate. A more individualised form of instruction is needed to optimize the educational [illegible] in a pluralistic society where [illegible] exist among the student population.

Individualized [illegible] method of improving instruction. It is a philosophy of education [illegible] instruction according to the needs of the learner [illegible] [illegible] [illegible] [illegible] needs.

1.5.2 [illegible]

[illegible] the [illegible] Committee on Science [illegible] developed the guidelines for Science education for the Upper Primary and the Secondary [illegible] the [illegible]

Years of Schooling — Guidelines for Upper Primary and Secondary Classes. On the basis of these documents, the NCERT developed new curricular and instructional materials for achieving the goals and objectives of the NPE 1986.

At the State level, the Directorates of Education, the Institutes of Science Education, State Councils of Educational Research and Training, Boards of Education, Departments of Education, Textbook Development Corporations and other such organizations are working in the field of science education and are responsible for the improvement of programmes and curricula. Some of the agencies which are directly involved in the implementation of the science education programmes at the State level include:

Curriculum Developers	Science Consultants, Science Committees, SCERT/SIE subject experts, subject teachers, and developers of materials
Educators of Teachers	[illegible] and [illegible] teacher education, in state education services, and teacher training colleges
Administrators	Directors of Education, Deputy Directors of Education, District Education Officers, Inspectors of Schools, Science Supervisors, etc.

The [illegible] and harmonious efforts of all these agencies in the implementation of these policies, aiming at improvement, are required in the following aspects of science education:

(a) Curriculum development in the teaching of Science

(b) Science Teacher Training

(c) Teaching-Learning Strategies in Science

(d) Laboratory Work in Science

(e) Evaluation in Science Teaching

(f) Management of Science Education

Guidelines for achieving excellence in these six important areas of the science education programme are provided in the subsequent chapters of this book.

CHAPTER 2

Curriculum Development In Science

Science is dynamic in its nature. The knowledge of science keeps on changing, the existing knowledge being continuously modified and new knowledge added. Scientific advancement and technological progress necessitate modernization, and therefore the restructuring and updating of the curriculum is demanded from time to time. This nature of science requires the science curriculum to be dynamic enough to respond to the changes in contemporary science. It should also respond equally well to the changing goals of general education.

2.1 Abilities Expected to be Developed through Science Teaching

Science education should develop well-defined abilities in the cognitive, affective and psychomotor domains. It has been visualized that a person with scientific literacy after ten years of schooling must have the following seven abilities which have been identified by Yash Pal Committee constituted by the Department of education in science and mathematics NCERT, and described in its report.

1. The ability to understand the following nature of scientific knowledge:

   Science is tentative, public, replicable, probabilistic, humanistic and empirical.

2. The ability to properly apply appropriate science concepts, principles laws and theories in interacting with the environment.
3. The ability to use the process of science in daily-life situations in solving problems, making decisions and extending one's own understanding. The different components of the process of science are

   Classifying, communicating, controlling variables, defining operationally, designing experiments, formulating models, hypothesizing, inferring, interpreting data, measuring, observing, predicting, questioning, using numbers, using the space-time relationship.

4. The ability to interact with various aspects of the environment in a way that is consistent with the following values that underline science:

Longing to know and understand, questioning of all things, search for data and their meaning, demand for verification, respect for logic, consideration of premises and consequences.

5. The ability to understand and appreciate the joint enterprise of science and technology and the interrelationships of these with each other and with other aspects of society. These factors of interrelationship among science, technology and society are:

   Relationship between science and technology, verifiable propositions, social influence of science and technology, ultimate value of science knowledge, impact of science and technology, science requires openness, societal control of technology, public understanding gap, resources for science/technology, limitations of science and technology, scientists and technologists are human, science/technology and natural resources, science and other realms.

6. Develop a richer, more satisfying and more exciting view of the universe and continue science education throughout life. The factors necessary for development of such a view are:

   Interest, confidence, media preference, explanation preference, avocation, continuous learner, response preference, new preference.

7. Develop the following manipulative skills:

   Using of simple machines (screwdriver, saw, corkscrew), measuring skills (with knowledge of units used for various measurements), use of common agricultural implements used for preparing soil, sowing, threshing, irrigating, harvesting and storing, maintenance of bullock-carts, cycle and scooter, changing of fuse wire, using thermometer and balance, handling domestic animals, use and care of microscope, meter stick, camera, calculator, tape-recorder, use of the following equipments — graduated cylinder, timing device, sphygmomanometer, oscilloscope, any instrument that records data as a function of time, ammeter, some electronic instrument (like pH meter) that measures current as a function of some other physical variable.

The content and the learning situations pertaining to the above listed competencies have been discussed in a separate publication entitled *Science Education for the First Ten Years of Schooling* developed in the DESM (NCERT) in 1987. The facts, methods and practice of science should be used as tools for developing the abilities and values already stated. Scientific knowledge should also help an individual to question the existing beliefs, prejudices and practices. It should also help the child to search for truth and order in different aspects of life to make it more harmonious.

At the Upper Primary stage, the child is expected to consolidate and strengthen the abilities acquired earlier. The objective should be to develop an understanding of certain physical, chemical and biological principles and their re[illegible] as in daily life. The child should also [illegible] in designing simple experiments [illegible] of natural phenomena.

At the Secondary stage, the learner should be able to understand further the basic structure and principles of science, with special reference to the relation of science to agriculture, industry and technology. The teaching of science should develop an insight into health and environment. More stress should be laid on precision and accuracy of quantitative measurements, on collection, presentation and analysis of data and on drawing inferences from them. The learner should develop the ability of problem solving.

2.2 Common Core Components

India is a vast country with wide variations in its different parts with respect to language, religion, culture and socio-economic status. Some of these have indirectly affected our educational endeavour. It is essential to bring comparability in the educational standards across different regions. One common curriculum cannot be implemented in all parts of India due to the existing diversities and disparities. The curricular efforts should be directed to promote national integration, social fusion and cultivation of values as enshrined in the constitution. The curriculum should be centered around the essential learning outcomes for all learners as mentioned earlier in regard to the abilities to be developed.

However, the curriculum should be characterized by a great degree of flexibility in respect of content and design and should be based on local situations.

The following are the common are components to be encompassed in a curriculum: (i) India's common cultural heritage, (ii) egalitarianism, (iii) democracy and secularism, (iv) equality of sexes, (v) protection of the environment, (vi) removal of social barriers, (vii) observance of a small-family norm and (viii) inculcation of the scientific temper.

2.3 Efforts of the NCERT

In the direction of curriculum development in science, the Department of Education in Science [illegible] NCERT developed [illegible] Upper Primary and [illegible] teacher's guide [illegible] learning [illegible] activity.

2.4 The Role of the States in Implementing the New Science Curriculum

The science curriculum developed by the NCERT for the Upper Primary and Secondary stages cannot be implemented in every state of the country due to the large diversities in educational facilities and disparities in culture, in socio-economic standards and, above all in the physical environment. The States may therefore adapt the NCERT curriculum. In these cases, the core curriculum consisting of the basic principles and laws of science, should be retained in order to maintain the minimum educational standard of the learners. The common principles and laws of science should be developed in textbooks on the basis of the things, occurrences and experiences of the learners in the immediate environment. Changes or additions of examples may be made by incorporating topics of local importance. The curriculum developers, while developing the science content, should keep in mind that the content of the curriculum is the medium through which the goals of general education, laid down in the NPE-1986, have to be achieved.

2.5 Modes of Development of Curricular Materials

There are various modes for the development of curricular materials. Two main modes are discussed here.

(a) Through writers workshops
(b) Through the identified authors

2.5.1 Through Writers Workshops

A writers' workshop, consisting of about 20 participating members (subject experts, practising teachers, method masters, persons working in voluntary agencies) may be organized by the State Education authorities responsible for developing the curriculum. The duration of this workshop may be 10-15 days, depending on the content to be covered. In the beginning, the workshop members may be exposed (through documents sent in advance) to, (i) the philosophy of the science courses, (ii) the basic principles of developing curricular materials, (iii) the pedagogical considerations, and (iv) a format for developing the material through various lectures. Then the participants may be divided into groups and allotted one to two units of the subject each. The groups should prepare the concepts and sub-concepts for the units allotted to them. These concepts and sub-concepts should then be discussed in the whole group for modification. After this, each participating member should write the material on each sub-concept of the unit allotted to him/her in a commonly agreed style and format. Finally, the entire material should be edited by a team consisting of two to three members. The first edition of this book may be treated as an experimental edition. After a try-out for one academic session, the material may be revised on the basis of the feedback received.

2.5.2 Through Identified Authors

The State educational age[illegible] may identify the authors from among persons who [illegible]ng research work in some area of science or science education. An experienced senior person may be identified to act as the chairman of a writing team. The authors and the chairman of the [illegible] syllabus vis-a-vis the objective of science teaching mentioned in the [illegible] achieving the goals of science teaching. Next the format for writing [illegible] dividing the whole syllabus into units, each author may be assigned one to three units. All the authors would write the required materials in a pre decided format After all the units are written, the State agency may organize a workshop to get the whole manuscript reviewed The authors may finalise the units according to the suggestions received in the workshop. Finally, the editor(s) may edit the material and make it pressworthy

2.5.3 Guidelines for the Preparation of Instructional Material

The writing of instructional material is a highly technical work Given below are a few important points which will help the authors in writing good material

I The Textbook

1 The author should state the learning/objectives for the unit in the beginning.
2. The topics should be presented in such a way that abstract/formal concepts are preceded by concrete materials and analogies existing in the immediate environment.
3. Simple activities may be given wherever possible.
4. The inter disciplinary approach should be given due consideration.
5. Proper illustrations should be given wherever necessary
6. An adequate number of diagrams, graphs and charts should be used to convey the idea of a concept. Illustrations should not constitute more than 33 per cent of the written material
7. Each section in the unit should be followed by a set of questions to test comprehension of the content given in it.
8 Questions should also be given at the end of the unit These questions should be of all types — knowledge, comprehension, application, analysis
9 There should be problems intended to develop problem-solving ability.

II The Teacher's Guide

The teachers' guide is meant to guide a teacher in using a particular textbook The material in the Teachers' Guide provides suggestions to teachers which help him in more effective planning and teaching the subject It also provides more examples related to a concept; analogies, elaborate explanations of the concepts, and demonstration experiments Each unit in the Teachers' Guide should correspond to a unit of the textbook without duplicating the material. The Teachers' Guide may be developed on the following lines

(A) The Introduction

It provides a brief overview of the unit with special reference to the content and highlights its points of approach The introduction should be motivating and should bring out clearly the aims of teaching the unit.

(B) Objectives

The objectives to be achieved are given in behavioural terms in each unit.

(C) The Content and its Presentation

The content provides guidelines to the teacher for step-wise presentation of the subject matter in terms of alternative approaches, demonstration, improvised experiments, models, charts and student activities. The additional material, wherever necessary, is also included to make the subject matter more comprehensive and easily understandable.

(D) References

The names of books, popular journals and magazines may be provided at the end of each unit.

IV. The Evaluation Material

Formative evaluation measures the extent to which the objectives of a unit have been achieved. Summative evaluation measures the final outcome of learning by pupils. The evaluation material helps a teacher in both formative and summative evaluation of his/her pupils.

The availability of good questions, therefore, is considered necessary. The convenient way for providing this is to develop a collection of questions to cover all intellectual abilities. There are six different abilities — knowledge, comprehension, application, analysis, synthesis and evaluation.

Types of Questions — Items and Guidelines for Their Construction

The term 'question' is associated with the short- and long-answer type questions, while the term 'item' is associated with the objective type questions. There are, however, two types of questions/items:

(i) Selection type
(ii) Supply type

Selection Type

These are items which [illegible] the learner [illegible] [illegible]. The [illegible] type [illegible]. Selection type items may be [illegible] (ii) [illegible] items, (iii) multiple choice items, and (iv) arrangement items.

(i) *Constant Alternative Items*: [illegible] alternatives. The [illegible]. The items of this type [illegible] judge [illegible].

ii) *Matching Items* This type of item consists of two lists in two columns The student is required to match the contents of one list with those of the other The items must specify the basis of matching and type of matching

(iii) *Multiple Choice Items* A multiple choice item consists (a) a stem which is written at the top of the item either in the form of a direct question or an incomplete statement, and: (b) three to five options, given one below the other. The options contain one right answer, the remaining three to four being distractors. The stem may be a direct question or an incomplete statement In the stem negatives should be avoided Anything that needs to be repeated in each option should be included in the stem The 'distractors' must act as 'distractors' to students of the higher ability group and as 'attractors' to those of the lower ability group. The correct answer should not be clearly visible from its length or precision Further, the correct answers are randomly arranged

All the options should have the same kind of relationship to the stem, with respect to content-matter and language They should fit with the stem in terms of tense, article and grammatical form The answer in the option must be correct beyond any argument The distractors must be incorrect but similar to the correct answer For this, the common misconceptions and common errors of students may be used in distractors The use of the words 'all of these' or 'none of the above' should be avoided as far as possible.

(iv) *Rearrangement Items* : In these items, the student is required to arrange the randomly presented subject material. The rearrangement may be in terms of size, order of events/reactivity/magnitude, etc

Supply Type Items/Questions

This type of item requires answers to be supplied The form of the answer may be a single word, a phrase, a sentence or an essay These items/questions may be divided into the following five categories. (i) Simple questions, (ii) Completion, (iii) Short Answer, (iv) Long Answer, and (v) Problem-solving

(i) *Simple Questions* The simple questions have short and clear-cut answers. These are direct questions, with the answers related to the main point in the question

(ii) *Completion Type Items* In these, the student has to provide a word, a number or a phrase in the blank space provided in the question The blank space should be adequate enough to accommodate the answer Shorter or longer blank space than required for the answer sometimes misleads the students.

(iii) *Short Answer Items/Questions* This type requires a very short answer in the form of either a few sentences or a diagram or a small numerical The statement of the question must be clear The use of the words 'briefly' 'short notes' etc is avoided The scope of the answer must be limited

(iv) *Long Answer Questions* These are essay type questions, requiring long answers. The questions in this category should have unrestricted response. In addition to testing knowledge, the higher mental abilities of students can also be tested by this type of item. Action verbs like 'contrast', 'discriminate', 'compare', 'explain', 'prove', 'show why' (or how), 'define', 'refute', etc., may be used in writing this type of question. Phrases like 'discuss briefly', 'write an essay', 'explain briefly', etc. may be avoided. The question should be specific and unambiguous.

(v) *Problem-solving Items* A situation representing a problem is given as a question. The problems may be open-ended or close-ended. Open-ended problems have more than one solution, whereas close-ended problem has only one solution. The problems should be open-ended as far as possible. Problems given in the textbooks should be avoided.

IV Development of Supplementary Reading Material

Everything cannot be put in a textbook. Many students would like to know more on a particular topic. Supplementary reading materials should serve this purpose. Also, one of the important recommendations of the NPE-1986 is that children with special talent or aptitude should provided the opportunities to proceed at a faster pace by making good quality education available to them. On the other hand, the slow learners and first-generation learners should be allowed to set their own pace. Different kinds of supplementary reading and culturally compatible science education material can be developed for the two categories of learners. The learners with special talent may be provided the material which emphasizes the application of science and helps to develop the higher mental abilities. These students may also carry out project work and participate in out-of-school science activities such as science exhibitions, science club and debates on current topics of science. Material that provides guidelines for these activities may be developed and given to the students. A special kind of enrichment/supplementary material containing current information on important science topics may also be developed and made available to them.

Given below is a list of suggested topics on which the enrichment materials can be developed for Upper Primary and Secondary stages. However, the depth and treatment of content matter will vary for the two stages.

List of Suggested Topics for Supplementary Reading Materials

1 *Energy and Energy Resources*

Importance of energy, source of energy, wood, coal, petroleum, nuclear, geothermal and energy, wind energy, hydroelectric and solar energy, etc. biodegradable sources, places, purposes for which these sources of energy are used, fuel efficiency; merits and demerits of various sources of energy, Conservation of energy

2 Environmental Pollution

ture's balance and its disturbance as a cause of pollution, air and water pollution, pollutants, ection of pollutants, Silent Valley project, Chipko movement, cleaning of Ganga project, rmada valley project

3 Long-term Strategies for Solving Food Shortage

ood resources versus population; factors affecting:

(a) food shortage
(b) food production
(c) food preservation
(d) crop protection
(e) modern agricultural practices
(f) small family norms

4 Science-based Hobbies

(a) Gardening: plant collection, grafting and breeding experiments.
(b) Pollution study.
(c) Ecological survey
(d) Interactive charts and models
(e) Rearing of animals

5 The World of Microscopic Organisms and Viruses

Cell, different types of cells, tissue, single-celled organisms such as amoeba, paramecium, bacteria, yeast, etc.; life history, culturing, economic importance

6 The Plants Around Us

Different types of plants with their common names, habit and habitat, vegetative and floral structure, seasons in which they are available, economic importance

7 Biotechnology in the Modern World

Bio-energy: Gobar gas, energy from waste, use of microbes in dairy, bakery, beverage, leather, medicine, agriculture, genetic engineering, etc.

8 The Universe

The solar system, planets and planetary orbits, differences between planets, stars and satellites, the Milky Way and galaxies, eclipses, the importance of artificial satellites for mankind, weightlessness, space research in India and in other countries.

9 Atom and Atomic Energy

The atom is the fundamental particle of matter, the story of an atom, binding energy of a nucleus, natural disintegration Uranium, nuclear reactions control of nuclear reactions, nuclear fuel, disposal of nuclear products and its problems, atomic energy for peaceful purposes

10 Plastics and Fibres

Replacement of metal components by plastic material, simple plastics and fibre chemical materials, principles of their preparation, important properties such as tensile strength, elasticity, thermal stability etc., use of plastics and fibres vis-a-vis their properties

11 The Natural Wealth of India

12 Metals and Minerals

Distribution of elements in nature, ores and minerals and their places of occurrence, percentage composition of elements present in ores and minerals, consumption – - how much consumed in India and how much exported? Applications of natural resources in life, agricultural wealth, fossil fuels, conservation of natural wealth

13 Science in Everyday Life

Domestic -- kitchen, cleaning and washing agents, human health and hygiene Electricity, transportation, communication, clothing, housing etc

The slow learners should be provided with a different kind of supplementary material that will help them to set their own pace The materials under this category should bridge the gap between the previous knowledge of the learners and that required for understanding the present science curriculum Attempts should be made to relate the content with their surroundings, giving more lucid and familiar examples and concrete materials.

The supplementary reading materials may be developed either through workshops or by commissioning authors followed by revising and editing.

Science Teachers' Training

Teacher is the most important link between the curriculum planners and developers and the ultimate users of the curriculum (the students). He plays a key role in the implementation of various programmes in both the formal and the non formal education systems. The main role of teachers is teaching and guidance to their pupils, not only through classroom instruction and tutorials but also through personal contact, and in many other ways. It is, therefore, necessary for teacher to remain in touch with the latest developments in content, educational innovations, teaching-learning methodologies, evaluation, examination reform etc., through different contact programmes, refresher courses, and training and orientation courses.

3.1 Present Status of Teachers' Training

There are different agencies like States Councils of Educational Research and Training, Directorates of Education, Colleges of Education, etc., in the States that look after the in-service training of teachers depending on the nature of the programme and the convenience of the State authorities. There are about 1200 institutions in the country for the training of elementary school teachers and 360 colleges for preparing secondary teachers. A large number of these institutions do not have a well-equipped science laboratory where practical experiments can be performed. It is wrongly presumed that the teacher-trainees have learnt enough content, both theory and practical, in the science subjects in their Bachelor's degree course, and so no further discussion of content of performance of experiments is needed in the teacher training colleges. It is also presumed that teacher-trainees will be able to decide which techniques and approaches are to be used in different units and that they will be able to apply conveniently the principles of methodology while teaching without any further academic inputs in terms of new ideas.

3.2 Policy Recommendations on Teachers' Training

The following recommendations are given in the NPE-1986 in regard to teacher education.

1. Teachers should have the freedom to innovate, to devise appropriate methods of communication and activities relevant to the needs and capabilities and concerns of the community.

2. Teacher education is a continuous process, and its pre-service and in-service components are inseparable. As the first step, the system of teacher education will be overhandled.
3. The new programmes of teacher education will emphasise continuing education and the need for teachers to meet the thrusts envisaged in the policy.
4. Districts Institutes of Education and Training (DIETs) will be established with the capability to organise pre- service and in service courses for elementary school teachers and for personnel working in non-formal and adult education. As the DIETS get established, sub standard institutions will be phased out. Selected secondary teachers' training colleges will be upgraded to complement the work of the State councils of Educational Research and Training. The National Council of Teacher Education will be provided with the necessary resources and capabilities to accredit institutions of teacher education and provide guidance regarding curricula and methods.

The NPE-1986 places complete trust in the teaching community. It calls for a substantial improvement in the quality of teacher education. The policy also emphasizes the teachers' accountability to the pupils, to their parents, to the community and to their own profession. Keeping in view the central place of teacher education in the total education system, the NPE-1986 calls for its overhaul as the first step towards educational reorganization. The need for teacher training arises from several sources, such as the changing national goals, revision of school curricula, additional inputs in the teaching-learning system, inadequate background of teachers, etc. For implementing the recommendations the following operational strategies are envisaged in another document entitled "Programme of Action".

1. The State Councils of Educational Research and Training (SCERTs) would have a major role in planning, sponsoring, monitoring and evaluating the in service education programme for all levels of teachers, instructors and other educational personnel. The State-level agencies would take into consideration all the needs of teachers before preparing a programme of in-service education for a given period of time.
2. The SCERTs would prepare suitable materials for the in- service education of teachers and key persons, keeping in view the needs of the teachers to handle the new curriculum effectively.
3. In addition to the above efforts, the SCERTs would also utilise the experiences especially those of voluntary organisations involved in doing similar work in designing courses, development of materials and strategies for in- service education.
4. All in-service education programmes cannot be organised in the face-to-face modality, especially in view of the large number of teachers involved. Distance in service education will therefore be prepared and extended with the help of broadcasting agencies.
5. The new programmes of teacher education will emphasize continuing education and the need for teachers to meet the thrusts envisaged in the NPE-1986

3.5 Suggestions to the States for the Training of Teachers

In view of the new curricula and the new approach and philosophy of teaching science in schools upto ten years of compulsory schooling, it is essential to intensify and reorganise both pre-service and in-service teacher training programmes in the framework suggested in NPE

(A) Pre-service Training of Teachers

Professional training is a pre-requisite for elementary and secondary teachers in all parts of the country. District Institutes of Education and Training (DIETs) are being established with the financial aid from the Central Government. These institutes are being provided the facilities to organize pre-service and in-service training for elementary school teachers. The training for secondary teachers should continue to be looked after by teacher institutions affiliated to the universities.

The following steps may be taken to improve and strengthen pre-service training

1 The existing syllabi of the teacher-training institutions should be revised in the light of the new curriculum developed for science under the ten years' compulsory schooling programmes
2 The present system of dealing with content and methodology as two distinct branches of training should be abolished. Content cum-methodology and evaluation should be taught together in the teacher training colleges.
3 The teachers should be trained to use all possible methodologies to explain the science concepts included in their content syllabi.
4 Activity-based methodologies should be practiced for teaching scientific concepts
5 The [illegible] should be such that they could be practiced in the actual clas[illegible] schools. The time available to the teachers during the actual classroom teaching must be kept in mind while suggesting and devising methodologies
6 The present system of preparing lesson plans should be made flexible with respect to the teaching methodologies and activities. Such plans should include meaningful evaluation
7 Competency in the use of science kits for performing different experiments should be made a prime condition for successful completion of the training
8 Adequate reading material on teaching of science should be made available.
9. There should be liaison between the teacher training institutions, Boards of Education, SCERTs and other agencies working in the field of school education to bring about necessary changes in teacher training programmes as per requirements
10 Each teacher-training institution should have at least one teacher in each science discipline, i e physics, chemistry and biology with the qualification of M.Sc , M.Ed
11 There should be provision for a teacher educator to go as a teacher to teach in the actual classroom for 1-2 years after every 4-5 years.

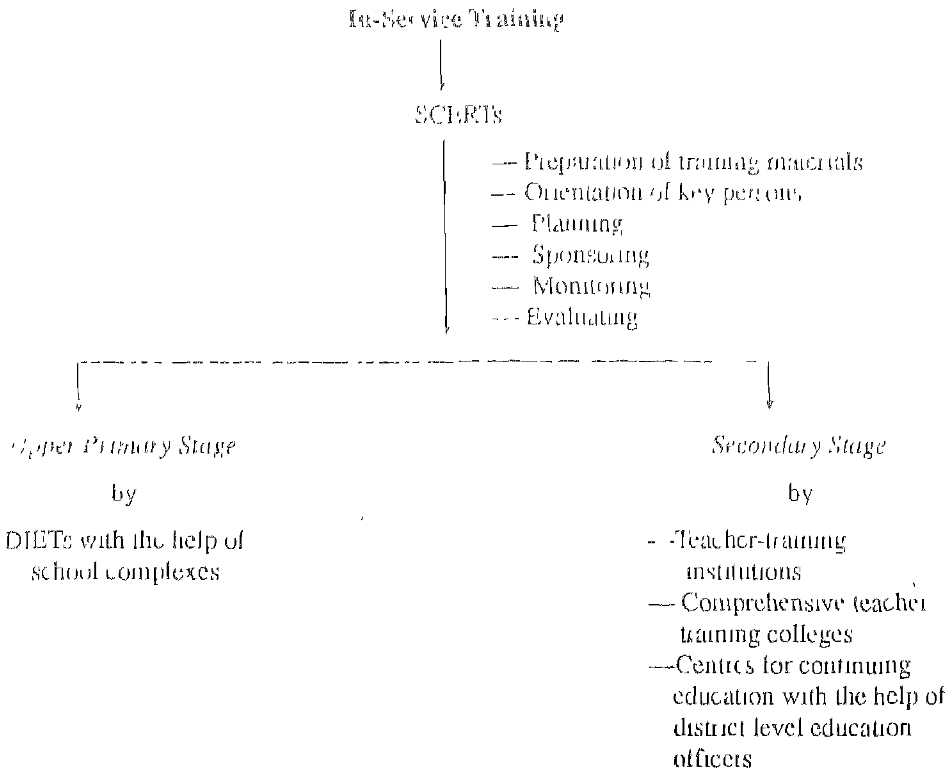
12 The methodologies of teaching should be taught as a practical subject

13 All the teacher training colleges should have a well equipped science laboratory where practical experiments can be performed

(B) In Service Training of Teachers

At the national level, under a centrally sponsored scheme of in service training of school teachers, a large number of teachers are being trained They perceive their role with regard to the specific action to be taken by them for successful implementation of the programme of education

1 At the state level the following model is suggested for the in-service training of teachers


In-Service Training
SCERTs
— Preparation of training materials
— Orientation of key persons
— Planning
— Sponsoring
— Monitoring
— Evaluating
Upper Primary Stage
by
DIETs with the help of school complexes
Secondary Stage
by
- Teacher-training institutions
— Comprehensive teacher training colleges
— Centres for continuing education with the help of district level education officers

2 The new curriculum may be implemented in a phased manner. For Classes VI, VII, IX and XI, it may be implemented in first phase The implementation in Classes VIII, X and XII may be implemented in the second phase. This will require the training

of a large number of teachers related to the teaching of these classes. Training of such a large number of teachers by face-to-face contact may be difficult in view of the short time available with the States.

It is therefore, suggested that correspondence-cum-contact programmes could be organised. Suitable materials may be prepared by the SCERTs and sent to the teachers in advance. The teachers may be asked to go through the material and prepare notes and identify difficult portions. They should then be called for a short-term contact programme where they should first be tested for judging their understanding of the materials sent. Activities could then be performed during this contact programme, and portions which the teachers felt to be difficult could be discussed with them. The school complexes or Government Higher Secondary Schools should be used by the States for training a large number of Upper Primary teachers in a short period.

3. Programmes for distance in-service education could also be prepared by the SCERTs and then extended to the teachers with the help of broadcasting agencies. For this purpose, the SCERTs would be equipped with necessary resources for the production of learning material.

Working in tune with the Psychology of the Teachers

It is essential to organize and work in the teachers' training programmes in tune with the psychology of the teachers. Many teachers feel that teaching through activities is not conducive to learning [illegible]. They feel that in a period of 35-40 minutes' duration they can give more knowledge (information) by conventional means as compared to that given through the activities. [illegible] In carrying out activities, a student learns much more and gets a chance to develop [illegible] the required abilities and skills. We should pass on this idea to the teachers in [illegible] programmes in a way which will not hurt their feelings but will at the same time change their attitude towards teaching through activities. It requires repeated efforts. To begin [illegible] may fix a block of two periods for activities once in 20 days in the school timetable. [illegible] the students will get a chance to perform 20-25 activities in a year.

In teacher training programmes, the teachers may be at least made conversant with or exposed to all the 20-25 activities though it may not be possible for an individual teacher to carry out all of them. Therefore different groups of teachers may carry out different activities and this may be followed by a group discussion. In this way all the teachers will at least be exposed to all the activities.

A drastic deviation from the existing system or the existing psychology of the teacher is not immediately possible. We cannot expect a teacher to deviate too much from what he has been doing for the last 15-20 years. He has his own rigid ideas of teaching a particular topic. The teacher educators should attempt to bring about a gradual change in the teachers. For this they may identify some innovative teachers who keep on trying new ideas in the classroom and also keep themselves up to date in content and methodology. The teacher educators may find out from these innovative teachers in discussions as to what they have been doing in the last ten years to keep themselves upto the mark. This discussion may be recorded on an audiocassette and then placed before other teachers so that they might know that it is possible to do better in the existing system. Likewise, one can record a topic being taught by an innovative teacher, and the other teachers may be exposed to this. These are some of the ways in which one can work in tune with the psychology of the teachers and also bring about in them gradual attitudinal changes.

Science Content for Upper Primary and Secondary Stages Required for Teacher Training Programmes

On the basis of the syllabi suggested for the Upper Primary and the secondary classes by the NCERT, a few difficult concepts and a number of activities have been identified, which may be performed during the training programmes to enable teachers to undertake the classroom teaching of these concepts satisfactorily. These concepts and activities are listed in Annexures 3.1 and 3.2 at the end of this chapter.

During training, a great deal of emphasis should be laid on conveying the philosophy of science teaching up to the secondary classes, and examples from the syllabi should be used to develop this philosophy during teacher training. The method of developing identified competencies for different levels using the syllabi should be explained to the teachers, with examples. Competencies should be the focus, and the syllabi a means towards it.

For example, consider classification. In the syllabus, this concept is given at a number of places such as classification of matter in elements, mixture and compounds, classification of substances [illegible], etc. The objective is to develop in students the ability of classification by using the classification of matter or acids and bases as the content material. The students should be able to classify objects, materials or even any data based on some parameters. This concept may be taught through activities starting from the classification of concrete objects. The students are asked to classify them on the basis of some observable property such as colour, size, shape, state, etc. Then these objects may be classified on the basis of some abstract properties. These activities are a means of developing many other abilities which are not directly mentioned in textbooks.

ANNEXURE 3.1

Suggested Programme Schedule for 15-days In-service Training Programme for Upper Primary Science Teachers

Day	Forenoon Session	Afternoon Session
1st	Introduction to the programme	Highlights of science as a compulsory subject for the first ten years of education as visualised in NPE-1986
2nd	Learner-centred science instruction	Practical activities on the 'Things Around Us' and 'Separation of Substances'
3rd	Using the environment as a resource for teaching science at the Upper Primary level	Practical activities on 'Measurement'
4th	Practical activities on Microbial and on the 'Living World'	Improvised teaching aids and their relevance to the Upper Primary science syllabus
5th	Preparation of some improvised teaching aids and their presentation in the group	Activities on 'Water'
6th	Guidelines for effective evaluation in science as per the NPE-1986	Practical activities on 'The Universe' and 'Heat'
7th	Preparation of evaluation items on units done so far and group discussion on these items	Practical activities on 'Motion, Force and Machine'
8th	Practical activities on 'Food, Health and Disease.'	Discussion on minimum laboratory requirements for the Upper Primary stage
9th	Preparing a sample of activity based work schedule for one session	Practical activity on 'Life Processes'
10th	Practical activities on 'Balance in Nature'	Preparing and discussing evaluation items on units done in the last ten days
11th	Practical activities on 'Electricity'	Discussion on teaching training strategies in the light of the NPE-1986
12th	Preparing some model [illegible] activities for students	Practical activities on 'Organisation of the Living Body'
13th	Discussion on the teaching strategy of a unit 'Rocks, Minerals and Metals'	Practical activities/paper pencil activities on the unit 'Rocks, Minerals and Metals'
14th	Practical activities on 'Conservation of Natural Resources'	Difficulties visualized in implementing the Upper Primary syllabus and their possible solutions
15th	Practical activities on 'Minerals and Air'	Preparing evaluation items on units of the last 14 days, and opinion of the participants regarding improvements in the future programmes

ANNEXURE 3.2

Suggested Programme Schedule for 15-days In-service Training Programme for Secondary Science Teachers

Day	Forenoon Session	Afternoon Session
1st	Introduction of the programme	Highlights of science as a compulsory subject for the first ten years of schooling as visualized in the NPE-1986
2nd	Learner-centred science education	Performance of activities on 'Matter, Nature and Behaviour' by the participants
3rd	Guidelines for effective evaluation in science as per the NPE-1986	Preparation of test items for different abilities, followed by group discussion
4th	Practical work in science at the Secondary Stage	Performance of activities on 'Motion'
5th	Performance of activities on 'Ways of Living'	Improvised teaching aids and their relevance to the Secondary science syllabus
6th	Preparing some improvised teaching aids by participants and their presentation to the group	Group discussion on improvisation
7th	'Natural resources' — lecture followed by group discussion	Performing activities on 'Electricity'
8th	Preparing evaluation items on units done so far and group discussion on these items	Performance of activities on 'Natural Resources'
9th	Performance of activities on 'Motion' by the participants	[illegible] minimum levels of learners requirements for the Secondary Stage
10th	Preparation of [illegible] activities [illegible] schedule for one session	Performance of activities on 'Nuclear Reactions'
11th	Performance of activities on [illegible]	Improvisation in science
12th	Performance of activities on 'Environment'	[illegible] teaching [illegible] as envisaged in the NPE-1986
13th	Preparing science material and resources for display and familiarisation	Performance of activities on 'Energy'
14th	Teaching strategies of 'Energy'	Difficulties visualized in implementing the 'Secondary science syllabus' and their possible solutions
15th	Performance of activities on 'Food and Health'	Preparing evaluation items on various units of the first [illegible] and the opinion of the participants for improvement in the future programmes

CHAPTER 4

Teaching-Learning Strategies

Science was introduced as a compulsory subject for the first ten years of school education as a part of general education following the recommendation of the Education Commission — *1964-66* (the Kothari Commission). But this could not be implemented in the right spirit due to several reasons. Now, the new changes in the science curriculum and the new demands of the society necessitate the use of new and more appropriate teaching learning strategies. Science education of the present time must meet the challenge of improving the scientific literacy of the society. The present-day science teaching is not merely telling. The new science curriculum emphasizes the learning of scientific principles and laws, correlating facts with principles and laws and latter applying principles to new situations. This requires the use of modern teaching-learning strategies in teaching science.

4.1 Policy Recommendations

The following recommendations have been given in the NPE-1986 regarding teaching-learning strategies:

1. A child-centered and activity based approach to learning should be adopted. First-generation learners should be allowed to set their own pace and be given supplementary remedial instruction.
2. Children with special talent or aptitude should be provided opportunities to proceed at a faster pace, by making good quality education available to them, irrespective of their capacity to pay for it.

4.2 Teaching-Learning Strategies For An Effective Teaching of Science

The new science curriculum has been designed in consonance with the levels of mental development of the child, in which topics are presented hierarchically on the basis of complexity from concrete to abstract. Methods must run parallel to the different stages of mental development of the child. *The transaction of the curriculum must involve the active participation of students in the* teaching-learning process. A more individualized form of instruction is needed to optimise the education of each student. Strategies necessary for developing the scientific temper and the scientific attitude, such as open-mindedness, intellectual honesty; the courage to question, respect for human dignity; the spirit of inquiry; the ability to design experiments, acquiring certain basic skills, developing interest, curiosity and the desire to know and understand, the urge to search for data, the willingness to verify, the habit of keen observation, strengthening one's own decision making power, etc , are to be evolved and implemented

In this context it is strongly felt that the following strategies may be adopted, depending on the nature of the content, the availability of resources (both material and human), the time available at the disposal of the teacher, the availability of instructional materials, the teachers' guide, etc.

4.2.1 Strategies for Laboratory-Oriented Instruction in Covering Some of the Topics from the Syllabus

Laboratory-Oriented instruction may be a structured one where specific ideas are given to students to verify certain facts, laws or principles This structured laboratory oriented instruction may be in the form of practical work of the verification type, or it may be guided discovery approach The purpose of such laboratory work would be to develop process skills in the students These process skills include observation, classification, measuring, predicting, inferring, etc.

The unstructured, laboratory oriented instruction will include open-ended activities or activities of an exploratory nature where the students will be given the freedom to explore ideas They will be able to give operational definition of problems, formulate hypothesis, deduce consequences, control variables, design and conduct experiments, collect data, organize, analyse and interpret data and to arrive at a dependable solution to the problem, to verify a hypothesis and draw conclusions

Since it is not always possible to make learning activity-oriented, the lecture method for imparting instruction has to be used with the caution that sufficient pupil participation be taken into consideration.

4.2.2 Lecture Method

(i) Lecture with question-answer.
(ii) Lecture with demonstration
(iii) Lecture using audio-visual aids (either prepared or collected) like filmstrips, slides, overhead projector, transparencies, charts, models (static or working), specimens, flannelographs, epidiascope, video tapes, tape recorder, TV or radio, motion films, or other exhibits
(iv) Lecture followed by individual or group activities (the classroom being converted into a laboratory)
(v) Lecture followed by group discussion. This group discussion may be initiated/organized by the teacher but it should be properly planned so as to encourage participation of all the pupils

4.2.3 Pupil Initiated Learning

The following activities are involved in pupil initiated learning:

(1) Programmed learning through programmed text
(2) Computer-assisted learning, using programmed software
(3) Using games and simulations.
(4) Independent study of reference books, science magazines and other literature under the guidance of the teachers
(5) Doing assignments at home/library
(6) Guided self study for mastery learning. Instruction may thus be individualized. Special programme such as remedial classes may be organized for the weaker children. Special material based on the application of knowledge acquired may be provided to the fast learners.

Group teaching techniques, brainstorming, quizzes initiated by the teacher, debates and panel discussions suitable to a particular content area can also be adopted.

4.2.4 *Teaching through out-of-school learning activities*

(1) Field trips/exploring the environment
(2) Project work – investigatory nature
constructive type like model making, chart preparation, etc.
collection of specimens
(3) Participation of students in science exhibitions at school, in science fairs/science clubs/community science centres, etc., at school, district and State or National levels.

The use of these teaching-learning strategies in science has been illustrated with examples from different units of Primary and Secondary science syllabi in Annexures 4.1 and 4.2 at the end of this chapter.

For a proper adoption of appropriate teaching-learning strategies, the State education authorities may consider the following recommendations:

(1) *Orientation courses to be organized at regular intervals for updating the teachers with new ideas and methodologies of teaching science. All teachers should* be granted full pay long term study leave. It will be necessary for them to go [illegible] in the utilization of study leave as specified in the Programme of Action (p. 180).
(2) Handbooks for teachers/teachers' guides to be prepared for each subject and for each class.
(3) [illegible] work material or workbooks may be prepared and distributed to [illegible] all the science teachers.

(4) Application of multi-media instructional materials, low-cost teaching aids, and other audio-visual aids to be encouraged.

(5) Proper diagnostic tests for students and remedial measures for weaker ones may be made.

(6) Several teaching skills may be developed through microteaching for the improvement of teaching competency, taking necessary help from training colleges.

(7) Mass media and out-of-school activities may be strengthened.

4.3 Suggestions for Implementation of Appropriate Teaching-Learning Strategies

The stress at the Upper Primary level should be on observations and simple correlations. This is due to the fact that children are in the process of transition from the concrete to the formal level of mental development. The activities should include making simple exhibits or models giving them an opportunity for development of psychomotor skills, classification of different objects with similar characteristics etc.

At the secondary level, emphasis should be on quantification of observed facts, such as measurement, use of measuring devices and deducting the related quantities. Presentation of scientific data in tabular form, in graphics or bar diagram, may also be included.

The emphasis at this stage should also be on interpolation of given data through its analysis and extrapolation of a given observation in different conditions. Abstraction may include thought experiments giving opportunity for developing an analytical bent of mind.

It is necessary to realize that content and methodology cannot be separated from each other. The teachers' guide should stress this aspect and give some representative examples.

A list of voluntary agencies/organizations along with the areas in which they specialize should be published for the benefit of the State functionaries. Voluntary agencies such as Kishore Bharati, Vikram A. Sarabhai Community Science Centre, etc., involved in various aspects of science education may prove to be of immense help.

These may also function as resource-cum-facility centres. They should function as resource centres for any academic activity such as obtaining scientific information or technical knowhow. It is therefore, necessary to equip these voluntary agencies with a good library, workshop and other facilities such as laboratories. Refresher programmes for teachers could also be held here. Teachers would be able to prepare models/exhibits or other teaching aids in these centres. The District Science Centres, therefore, must be equipped with qualified personnel. The access to the centre should be free and easy for students, teachers and members of the community. The District Science Centres should also organize training programmes for science teachers and formulate programmes to cater to the needs of brighter and weaker children.

Instead of laying more stress on content information, emphasis should be given to the learning of concepts. Curricular materials must reflect teaching/learning situations from both rural and urban areas. While teaching science, emphasis should be laid on linking science with the constitutional commitments and different areas of national development like agriculture, communication, transport, textile, chemicals, etc

Through different mass media, exhibitions and study tours, certain thrust areas like energy, environment, social forestry, wild life management should be highlighted to avoid environment crisis.

Activities and experimentation should form the main part of presentation in teaching science up to the Secondary level as far as possible

ANNEXURE 4 1

Suggested Teaching-Learning Strategies for a Few Concepts

UNIT — MATTER, NATURE AND BEHAVIOUR

- *Teacher-initiated group discussion* about substances which differ in their appearances, colour, etc
- *Lecture with models* showing structure of an atom
- *Lecture with charts*, diagrams or other possible aids
- *Demonstration with probing questions*, and testing of the solubility of ionic and covalent compounds in water
- *Group experiments*
- *Laboratory-oriented experiments* to study the reaction of metals with dilute acids
- *Discussion* on reactions
- *Individual participation* of pupils in balancing chemical equations
- *Pupil-initiated discussions* enabling the class to appreciate the importance of chemical reactions in nature, in transfer of energy and in the functioning of human body
- *Laboratory-oriented simple experiments* to prove that chemical changes are of different types
- *Demonstration* of Volta's experiments
- *Construction* of an electro-chemical cell with ready made parts or improvised parts
- *Discussion* with charts
- *Demonstration* of electrolysis (even with improvised apparatus), discussion with charts
- *Discussion on importance* of classification of elements
- *Lecture with charts* to show comparative sizes of atoms in a period and in a group (halogens and alkali metals)
- *Consolidating* the concepts with *projected aids* like filmstrips or transparencies
- *Conducting quizzes*.
- *Suggesting carry-home activities* to study the action of lime juice, vinegar, etc on cooking, washing soda, etc
- *To prepare* improvised voltameters at home

Annexure 4.2

UNIT — MOTION, FORCE and ENERGY

- *Discussion* on motion, with pupils participation with their daily life experiences.
- *Lecture* demonstrations with aids showing motion of the earth with reference to the Sun.
- *Individual participation* in computation of speed in familiar situations to bring out relationships between distance and time.
- *Simple demonstrations*
- *Numerical problem solving*
- *Discussion* with graph and chart as aids to show volume temperature relationship.
- *Discussion*, and deducing the three equations of motion
- *Discussion* — pupil initiated — on inertia.
- *Demonstration* to show resultant force of several forces acting on a body
- *Lecture* with graph as an aid.
- *Lecture* with probing questions deducing the relation between force, mass and acceleration
- *Demonstration* with spring balance.
- *Demonstration* with magnets.
- *Individuals* — numerical problem-solving consolidating the three laws with projected aids like filmstrips or transparencies.
- *Demonstration of work done* due to potential energy and kinetic energy
- *Pupil-initiated discussion* to list out day to-day examples
- *Demonstration* of wave motion
- *Demonstration* of reflection and refraction
- *Demonstration* of image formation
- *Lecture* with models.
- *Demonstration* of Newton's disc.
- *Using* the colour perception test (charts)
- *Lecture* with telescope, microscopes, pin-hole, camera, etc (Also improvised or low cost equipment can be used).
- *Field trip to an observatory* — nuclear fuel complex, visit to a thermal power station.
- *Carry home activities* like observing and studying wave motion, patterns in water, preparing pin hole camera, trying to improvise telescope, periscope, etc
- *Arranging lectures* with specialists related to energy sources and the community, thus bringing the community nearer

- *Games* regarding the conservation of energy — through snake and ladder games.

UNIT — FOOD AND HEALTH

Lecture with Question and Answer

During presentation, the teacher may raise appropriate questions about the different kinds of food and the importance of food. For example, why should food be preserved carefully? What are the harmful effects of eating stale and spoiled food? Questions on the harmful effects of tobacco, alcohol and drugs may be asked

Lecture with Demonstration

The following demonstrations may be shown in the class:

(i) Presence of fats, proteins and carbohydrates in food
(ii) Samples of different soils
(iii) Testing soil for salinity and alkalinity
(iv) Demonstration of spoiled bread and other food items due to fungal attack

Lecture Followed by Activities

(i) The activities could be demonstrated after the lecture. Carry-home activities may be assigned.
(ii) Collection of information regarding different kinds of foods.
(iii) List of the vegetables used daily and types of vitamins they provide.
(iv) List the food items consumed in a day that provide the minerals required in a normal diet.
(v) Making newspaper cuttings that show deficiency diseases
(vi) Visit to a nearby veterinary centre, dairy farm and poultry farm to study the different types of management.
(vii) Making a list of how food can be preserved.

Lecture Followed by Discussion

After the lecture, the following points may be discussed in the class:

(i) Nutritive value of carbohydrates, fats and proteins.
(ii) Protein requirement under different body conditions.
(iii) Calcium, iron and iodine requirements of normal diet.
(iv) Dietary requirements for the individual pupil.
(v) Deficiency diseases (using photographs drawing, charts, etc.).
(vi) Factors responsible for deficiency of nutrients
(vii) Consequences of excess fat consumption on the human system.
(viii) Wastage of food during storage and distribution.
(ix) Major and minor irrigation projects.
(x) Common plant diseases, their control and prevention.
(xi) Different methods of improving crop yield.
(xii) Diseases affecting crop yield.
(xiii) Harmful effects of eating spoiled food.
(xiv) Kidney and cardiac failure using paper cuttings
(xv) Water borne diseases.
(xvi) Harmful effects of tobacco, drugs etc.
(xvii) Educating the community on hygienic habits.

Lecture with Collection and Preparation of Audio-visual Aids

All the demonstrations, activities and discussions can be supplemented using charts, posters, pictures, diagrams, graphs, photographs

Group Discussion

(i) Collection of pictures, photographs and newspaper cuttings of common goods, diseases, fertilizers, irrigation projects, livestock, etc
(ii) Collecting information on the above by talking to concerned people, or observation or by reading books
(iii) Carrying out carry-home activities
(iv) Making charts on the various aspects of the unit
(v) Visiting hospitals, dairy farms, poultry farms, fields, etc
(vi) Making use of mass media like TV and radio for knowledge and understanding of the unit

Group Teaching Techniques

(i) Discussion Initiating the unit by asking brain storming questions following by discussions
(ii) Quiz Competitions may be conducted as quiz programmes on general knowledge questions on the unit
(iii) Debates may be conducted
(iv) Panel discussion may be conducted

Laboratory-Oriented Instruction

The demonstrations performed by the teacher may be taken up to individual laboratory work

Games and Simulation

Making a set of cards to show the importance of different classes of food and playing games with these card An example is given below

Fats	*Provide Energy*	*Store Heat*	*Build Body*
Carbohydrates		*Prevents goitre*	*etc*

CHAPTER 3

Experimental Work in Science Teaching

The National Policy on Education — 1986 has laid considerable emphasis on child-centered education and inculcation of the scientific temper in pupils at all stages of school education. Child-centered education involves the participation of learners in the teaching/learning process. Experimental work in science helps to inculcate the scientific temper and involves the learners in the teaching-learning process. It provides an opportunity to students to handle different items of scientific equipment, apparatus and other materials of science. The students participate in the actual work and develop an appreciation for the method and spirit of science. This provides them a greater understanding of scientific concepts. Experiments by pupils inside or outside the laboratory give them first hand experience which is essential for a proper understanding of the processes of science. A modern school science programme cannot be conceived without practical experimentation by the pupils. The aims of incorporating practical work in science teaching are as follows

1. It arouses and maintains the interest of students in learning science
2. It helps in the understanding of phenomena which become more concrete through experience.
3. It trains pupils in scientific methods — in recording accurate observations, collecting of data or evidence, analysing data, making a hypothesis and testing it, selecting useful and consistent evidence and drawing conclusions.
4. It helps in developing specific manipulate skills in handling apparatus and other scientific materials.
5. It provides an environment to pupils for exhibiting initiative, resourcefulness and cooperation
6. It helps develop qualities such as discipline, the team spirit, and orderliness
7. It inculcates some creative abilities in the children
8. It provides opportunities to design experiments and improve them
9. It [illegible] a critical attitude
10. It [illegible] self-reliance in students.
11. It provides experience in standard techniques and helps in consolidation of knowledge

The following skills may be developed in pupils through practical work in science:

1. The habit of keen observation
2. The handling/manipulation of apparatus
3. The setting up of experiments
4. The classification and tabulation of data
5. The ability to use and interpret graphs and charts
6. The skills involving all types of measurements
7. The ability to design experiments/models
8. The ability to interpret experimental data
9. The ability to improvise simple experiments
10. The collection/preservation skills
11. The drawing skills.

5.1 Present Status of Experimental Work

Science teaching is theory-oriented in most of the schools in our country. Practical work is not given its due importance in developing concepts and manipulative skills. This is due to the non-availability of facilities in the schools for doing practical work. In some of the States, however experimental work is prescribed as a part of the syllabus by the examining boards but its results are not indicated in the certificate. Other constraints in conducting practical work is that teachers are not given any preparation time for doing practicals. Teachers, being held responsible for any breakage of apparatus or equipment, do not dare to utilize them even if these (apparatus and equipment) are available in the schools. Besides this, teachers need to be adequately trained in implementing the practical-oriented curriculum. Adequate grants are also not available with schools for the purchase of materials and equipments required for practical work. The pupil-teacher ratio is so high that sometimes it is not feasible for the teachers to organize any experimental activity and involve students in individual practical work. Possibly, enough guidance is also not available to the teachers to supplement the practical work.

5.2 Facilities for Experimental Work

Laboratory Facilities

In the context of science teaching up to the Secondary level, at least a multipurpose science room should be provided to all schools. The science rooms should be equipped in such a way that all types of activities connected with learning science (such as theory class, demonstration and laboratory work) may be organized in this. The specifications of a science room are as follows. The schools may start the science room even if all its facilities are not available. The other facilities may be gathered gradually.

Specification of science room

1. A science room should possess adequate space (say 18 x 10 sq. metre) For 50 students to work smoothly.
2. A blackboard, a bulletin board, a demonstration table, a few writing-cum-working tables, sufficient stools, charts, etc., may be provided in the science room. The demonstration table should be well equipped with water taps, sink, power points, gas taps (where there is facility to facilitate easy demonstration). The working tables should be movable and should be so designed that they can be used both for doing experiments/activities as well as for students desk work.
3. There should be a provision for handling charts and diagrams and for placing projection equipments like overhead projector, film strip projector, etc.
4. Arrangements may be made for hanging black curtains to darken the science room or a part of it whenever necessary.
5. There should be two doors in the room to facilitate easy exit.
6. The room should get adequate natural light. There should be proper ventilation in the room.
7. The fixed side table near the window should have storage cupboards where apparatus, equipment and chemicals may be stored. Costly chemicals and apparatus, however, may be stored in the storeroom.
8. If possible, there should be provision for an aquarium, a terrarium, a science library and arrangements for growing plants and rearing animals in the school.

Other alternatives to science laboratory

As stated earlier, a large majority of schools in India do not have science laboratories. The State authorities may consider the following as alternatives to science laboratories.

1. Mobile science laboratory with at least the minimum facilities like science kits, equipments, etc. The mobile science laboratory van may visit the schools of each area twice a week.
2. The environment can be used as a laboratory outside the school in teaching some of the relevant topics from the syllabus.
3. Community Science Centres, Science Clubs, District Science Centres, etc. can serve the purpose to some extent.
4. Modern educational technology/mass media may be utilized for the purpose of showing demonstration experiments and activities in addition to other alternatives.
5. The classroom may be temporarily used as a place for carrying out the practicals whenever it is required.
6. The school may borrow scientific equipment or apparatus from the neighbouring schools, colleges or training colleges and return them after their use. Some of these institutions may even allow the school students to work in the laboratories.

7. Science kits supplied by the NCERT, the SCERT, the SISE, or a Voluntary Agency serve the purpose up to the Upper Primary stage.
   Science kits which serve as mini laboratories may be designed by the States also as per their science curriculum for the Primary and Upper Primary levels. Such kits should include apparatus, general laboratory equipments, improvised apparatus, containers, chemicals, etc. These kits will enable the teachers to perform demonstrations and experiments in the class. For imparting manipulative skills, such kits may also be provided to science rooms.

Improvisation of Experiments and Apparatus

Any sophisticated instrument not available in the school may be improvised from the locally available material and apparatus. Experiments may be conducted with this improvised equipment. This is, however, possible, where the experiment does not require too much of precision or it is of qualitative nature. Through improvisation, the students will develop certain manipulative skills as well. Improvisation would help in developing creative abilities in children. The improvisation may be done in the process of experimentation also. For example, in conducting a demonstration of the bell jar experiment to show transpiration, in the absence of a bell jar, a teacher may simply use a big wide mouthed plastic bottle, or the same experiment may be simply done by tightly covering a few leaves of a plant with a transparent polythene bag. Similarly, for conducting an experiment on the rate of transpiration (a more advanced activity for brighter children) using Ganong's Potometer, improvised apparatus may be used if sophisticated apparatus is not available. This improvisation requires only a wide mouthed glass bottle, a wooden scale (small size), a double bent glass tube/transparent plastic [illegible] with two holes, a small glass container and a little red ink.

In chemistry, a wide mouthed glass bottle may be used in place of Woulf's bottle for the preparation of gas. Plastic tubes can be used in place of glass tubes. Bottles and glasses could replace beakers and flasks.

Carry Home Science Activities

As an extension of classroom activity to daily life and in order to make learning more meaningful, a number of carry- home activities are suggested from selected science topics. These activities may prove to be an alternative for the laboratory work. The State functionaries may develop a number of such activities with the help of teachers and experts and pass them to the concerned teachers.

List of carry-home science activities

Following carry-home activities may be assigned to students:

1. Prepare of a list of examples on how science is used in everyday life.

2. Collect and classify the things around you on the basis of any of their common characteristics
3 Simple experiments for separation of the mixtures:
   (a) sand and flour
   (b) rice and stones
   (c) water and kerosene
   (d) butter from curd
4 Make measurements (like length, volume, area, mass, etc.) of solids and liquids.
5 List some of the changes taking place around you – physical/chemical changes.
6 List the different vehicles which you see on your way home, and note their relative speeds.
7 Give examples of how your family members use force or energy to do work, e.g., making chapati, washing clothes, etc
8 Locate, observe and note down examples of the principles of the lever used in daily life
9 Note down how simple machines like pulleys, axle, gear and sliding board are used in your surroundings
10 Collect specimens of plants (flowers, leaves) and preserve them
11 Study the various animals that you see around your house and note their feeding habits
12 Plant some seeds and observe the process of germination
13 Study the other modifications of roots and stems from some of the vegetables used at home
14 Study a stem modification experiment to show how plants vegetatively reproduce
15 Try out experiments to study how water can change its form due to heat (interchange of state of water)
16 In a nearby pond or field, observe the interdependence of plants and animals
17 List some of the common constellation at different times of the month
18 Test the properties of acids and alkalis at home, using curd, washing soda, baking soda, lemon juice, vinegar, etc.
19 Study the formation of shadows, using a candle or a bulb.
20 List things at home which are good or bad conductors of heat
21. Perform simple experiments on reflection using your mirror at home
22 List the various kinds of food you have eaten in any one week
23. Make a list of some of the common diseases you have seen people suffering from in your locality for the last one year. Write down the courses, and the measures to prevent such diseases
24 Collect some pictures on pollution, calamities, diseases, animals, plants, people, etc.
25. When you visit a poultry farm, a park, a garden, a dairy, a farm, a field, a lake, etc., note down the animals/plants particularly found there
26 Collect materials for the school bulletin-board

27. Make models of the kidney, heart etc., using soap, wheat dough, plasticine.
28. Give a list of some of the foods which are adulterated, and describe how they are adulterated
29. List some of the sources of energy used at home.
30. From the materials available at home, suggest some alternatives for: (1) pulleys, (2) balance pans, (3) measuring cylinders, (4) glass rods, (5) scales, (6) spirit lamp, (7) Newtons colour disc, (8) windmill.
31. Devise working models to demonstrate scientific principles and processes.

The Role of States

For proper implementation of the new child-centered and activity-based science curriculum, at least the minimum required laboratory facilities should be provided to each school by the state functionaries. The States should ensure that the science teachers get adequate training in laboratory techniques/use of audio-visual aids. Provision of laboratory attendants/assistants (at least one for all science classes in the school) may be made and their training be arranged.

In the existing situation there is no provision for a separate laboratory assistant at the Secondary level to look after the practical work in science laboratories. Laboratory assistants are provided only at the Senior Secondary level to look after the work in various science disciplines such as chemistry, physics and biology. Under the new education policy, the teaching of science up to the Secondary level has been conceived to be integrated in nature and, therefore, a science laboratory/science room has been recommended for the implementation of the science curriculum effectively. It is strongly felt that the laboratory assistant should assist the science teacher in practical/experimental work. The essential qualification of a laboratory assistant should be SSC with physics, chemistry and biology. Like science teachers, laboratory assistants should also be oriented or trained periodically to equip them with recent experimental techniques and innovative practices

5.5.1 Suggested Areas of Training for Laboratory Assistants

1. Knowledge of chemicals/apparatus/equipments used in teaching science and in experiments by children.
2. Capability of maintenance of, and minor repairs in, the laboratory.
3. Awareness of laboratory hazards and safety measures.
4. Preparing solutions, reagents, preserving specimens and assembling electrical circuits.
5. Awareness of sources from which necessary materials, specimens (seasonal) and chemicals may be procured.
6. Capability of setting up experiments and working as per the instructions of the science teachers.
7. Use of audio-visual devices.

State functionaries in institutions like the SCERTs/SISEs may design their own science kits based on their own curriculum, in collaboration with subject experts and practicing teachers. For this purpose, academic help may also be sought from other institutions like training colleges, universities and the NCERT

It is stressed that the recommendations given earlier are meant for both rural and urban areas. It needs to be appreciated, however, that the rural schools may not have facilities that are easily available to urban schools. The emphasis on non-formal activities, improvisation of apparatus and equipment, provision of kits and low-cost materials to schools in rural areas needs special mention. It is desirable that the State functionaries put in efforts to produce handbooks for rural schools, taking into account locally available resources and the local geography, human skills and expertise As a matter of fact, a rural environment may provide possibilities for developing skills in experimentation which are not readily accessible in urban areas. These may include the study of flora and fauna, crops and irrigation patterns, etc. It is, therefore, strongly recommended that there should be special enrichment programmes and development of learning/instructional materials (or supplementary materials) for rural school teachers. Special training programmes need to be arranged for teachers in rural schools highlighting the improvisation using local materials and resources, and also activities using the local environment.

CHAPTER 6

Evaluation

The main purpose of teaching is to change the student's behaviour in the desired direction Evaluation is the process of determining the extent to which the desired changes in the student's behaviour are being achieved For this purpose it is necessary that evaluation encompasses the entire range of the student's activities and experiences, both curricular and co-curricular It should cover all the dimensions of growth—cognitive, affective and psychomotor.

The traditional methods of evaluation tested learners only in the cognitive domain to the neglect of the affective and psychomotor domains Evaluation was used as a tool only for promoting students from one class to the next higher class at the end of the academic year The evaluation tools suffered from serious drawbacks in respect of reliability, validity and objectivity The outcome of this type of summative evaluation gives only a distorted image of the learner The main aim of evaluation is to improve the teaching-learning process in addition to the appraisal of the achievement of learners Evaluation is also concerned with the effects of a curriculum, a course, a method of instruction, etc , on the achievement

6.1 Policy Recommendations

The following recommendations have been given in National Policy on Education — 1986 to reform the evaluation process and examination reforms

1 The examination should be employed to bring about qualitative improvements in education
2 The examination system should ensure a method of assessment that is a valid and reliable measure of the student's development It should also be used as a powerful instrument for improving teaching and learning
3. The education process should be such that it is possible to
    (i) eliminate excessive element of chance and subjectivity
    (ii) de-emphasize memorisation

(iii) ensure continuous and comprehensive evaluation that incorporates both the scholastic and the non-scholastic aspects of education, spread over the total span of instructional time
(iv) be used by teachers, students and parents
(v) improve the conducting of the examination
(vi) introduce desired changes in instructional materials and methodology
(vii) introduce the semester system from the Secondary stage in a phased manner
(viii) use grades in place of marks.

6.2 The Policy and Strategies for Implementation

The policy visualiz[illegible] of the assessment of performance with the process of learning and teaching, and [illegible] of evaluation to bring about qualitative improvement in education In order to ensure that the method of assessment of the student's performance is valid and reliable, the following short-term measures and long-term reforms have been proposed in the Programme of Action (POA) for implementing the education policy

6.2.1 Short-term Measures

(i) Public examinations will continue to be held only at the levels of Classes X and XII
(ii) Decentralisation of the operations involved in the conduct of examinations may be done to make the system work more effectively
(iii) School Boards in certain States have set up a number of sub- centres to decentralise the conduct of examination Adoption of similar measures by other States will be pursued
(iv) In the event of decentralisation, the State Boards will continue to get the question papers set and printed, consolidate the results of examinations, and also undertake test checks on random basis of the functioning of the sub-centres, and
(v) Spot evaluation of answer-scripts will be done

6.2.2 Long-term Reforms

(i) The Boards will lay down the levels of attainment expected at Classes V, VIII, X and XII
(ii) The Boards will also prescribe the learning objectives
(iii) Abilities and proficiencies which can and should be assessed through institutional evaluation will be identified and procedures evolved for such evaluation
(iv) Research and development in evaluation procedures and in the conduct of examinations will be undertaken
(v) Along with the external examination, continuous institutional evaluation of the scholastic and non- scholastic aspects of evaluation will be introduced

(vi) Evaluation of the student's performance will move towards cumulative grading system.

6.2.3 Conduct of Examinations

(i) The possibility of introducing legislation to define various malpractices connected with examinations and treat them as congnizable and non-bailable offences will be considered.
(ii) Such laws will also, when enacted, make provision to prescribe the punishments for various offences under the law and to include these within its scope.
(iii) Innovations and experiments in the conduct of examinations, like printing and distribution of question papers with questions arranged in different sequences to avoid copying and other unfair means in the examination hall, will be undertaken.

In the light of the reforms suggested in the Programme of Action of the NPE-1986, the following guidelines are suggested for the benefit of the States:

1. Evaluation may be considered as an integral part of the teaching-learning process for its improvement. The continuous formative evaluation may be introduced. It may be used to assess the progress of the individual student and also for prescription of remedial study for weak students.
2. Intensive in-service training for the classroom teachers may be organized to acquaint them with the recent methodology and technique of evaluation.
3. Research and development cell for continuous improvement in the approaches and operation may be established at SCERT.
4. In order to make the evaluation tools perfect in respect of validity, reliability and objectivity, comprehensive training of paper-setters may be organised.
5. The non-scholastic aspects of science may be given due importance. Adequate arrangements for planning and conducting the oral and observation tests for collecting trustworthy evidence about the pupils' achievement needs attention.

6.2.4 Pupils' Evaluation in Science

In the last decade, there has been a tremendous change in the techniques of evaluation, i.e., in conducting examinations, setting the question paper and assessing the various abilities of the students. The policy has recommended evaluation to be an integral part of the teaching-learning process. It should be in consonance with the approaches of teaching science. At the Upper Primary stage, the integrated science curriculum is followed. The curriculum is based on the environment surrounding the learner. The evaluation at this stage should comprise two parts:

1. Sessional work
2. The terminal examination

In sessional work, following activities may be evaluated

- (i) reports of the pupil's activities and the teacher's demonstrations
- (ii) collection and classification of specimens
- (iii) reports of visits to places of scientific interest
- (iv) written work
- (v) unit tests
- (vi) scientific attitude towards solving simple problems and interacting with the environment
- (vii) the scientific method in decision-making
- (viii) the assessment of experimental skills and understanding of science concepts involve activity-oriented tests. The experimental skills include the skill of handling apparatus such as the thermometer, the meter-stick, the graduated cylinder, the magnetic compass, etc , and conducting experiments

In the terminal examination, the pupils may be assessed through written and oral examinations. A proper weightage should be given to sessional work, activity-oriented tests and the terminal examination The Secondary stage (Classes IX-X) is the terminal stage for developing scientific literacy for the majority of the learners. Only a small percentage of students go in for the science stream after the Secondary stage.

The evaluation at the Secondary stage may consist of·

- (a) Sessional work and
- (b) The terminal examination.

The sessional work may include·

- (i) reports and records of pupils activities
- (ii) simple projects
- (iii) written work
- (iv) unit tests.

The terminal examination may be written as well as oral The practical examination may be conducted to test various skills At the secondary stage, as the child is at the formal operational stage of mental development, the evaluation in science should be in terms of originality, thoroughness in collecting data, organisation and summarization of data and reporting of findings The process of experimental work and the conclusions drawn should be given due importance. Emphasis may also be given to evaluate the following abilities in Secondary stage students

- (i) application of science concepts, laws and principles in interacting with environment
- (ii) the use of the scientific method in solving problems and making decisions.

(iii) application of the joint enterprise of science and technology and understanding their inter relations in other aspects of society

(iv) skills of manipulation and handling of scientific instruments and apparatus, and the ability to make simple improvisations.

(v) the manipulative skills of handling equipment such as the camera, the battery eliminator, etc , and the repairing of common household appliances.

.3 Evaluation of Curricular and Instructional Materials

Evaluation of curricular and instructional materials is an important aspect of the teaching-learning rocess. Textbooks are generally prescribed by the educational authorities and serve as an mportant source of teaching and learning of a subject It is, therefore, necessary that the State unctionaries at some point of time evaluate textbooks in order to determine their suitability and ppropriateness in their states The difficult concepts may be identified These may be made simpler by adding examples and analogues from local environment The formal-level science oncepts may be concretized and made understandable In addition to this, the evaluation of a extbook is aimed at answering the following general questions

1. Is the textbook suitable, too difficult or too easy for the level of students in that particular ability group?
2. Is the textbook written in accordance with the objectives and content laid down in the syllabus?
3. Does the textbook contain an adequate number of illustrations?
4. Does the textbook prepare students adequately for the public examination?
5. Does the textbook contain experiments/activities suitable to the content?

The main evaluation instruments take the form of a structured questionnaires to be answered by the teachers and students who are using a particular textbook A questionnaire (Questionnaire I) is given below for teachers for the evaluation on the use of textbook by the students

QUESTIONNAIRE I

Please tick (✓) in appropriate column

	How students use or find the textbook	Yes	No
1	Every student has a textbook		
2	Students appear to have difficulty in following the textbook		
3	Students raise questions regarding expressions (language) in the textbook that they cannot understand		
4	Students do not use or consult their textbook		
5	Students do not refer to the textbook when making notes or drawing diagrams		

In the new curriculum of science, major emphasis is given on activities and experiments. So it is essential to study and analyse carefully the content of the textbook or work book to find out how suitable and relevant are the given experiments or activities from the teachers and students point of view. For this purpose, a questionnaire (Questionnaire 2) for the teachers is given below.

QUESTIONNAIRE 2

Teacher's opinion to evaluate activities/experiments in science textbooks

Please tick (✓) in the appropriate column

If you strongly agree (SA) with statement, please tick the column under (SA). Similarly (A), (D) and (SD) stand for agree, disagree and strongly disagree respectively.

		SD	D	A	SA
1	Before I teach, I have to separate the simple experiments from the difficult ones				
2	Students only do experiments once in a while due to the shortage of materials and apparatus				
3	I usually have to spend most of my free periods preparing for practical demonstrations				
4	There is no need for me to check or change the experiments to suit the aims				
5	There is no problem of obtaining the materials from my laboratory				
6	I usually have to modify the experiments/activities because of lack of materials				
7	Students can often use the simple science concepts to build up the more difficult ones later on				
8	Sometimes, I have to cancel some of the experiments/activities because of lack of materials				
9	I usually find the experimental preparation a real burden compared to classroom teaching				
10	The improvisation in experiments and activities are really meaningful				
11	Very often the conclusions drawn from the experiments/activities done in the class are different from those stated in the book				

		SD	D	A	SA
12	Some of the objectives for the experiment do not usually agree with the experimental conclusion				
13	After the experiment the students can always answer test questions related to the objectives				

valuation of Teachers and Teaching

eachers are the implementers of all innovations in the classroom To a certain degree, they etermine the learning outcomes of students. Unless the teachers are equipped with enough nowledge on how to facilitate teaching learning situations, innovations will not be implemented s per the expectation.

. supervisor has an important role in the improvement of teachers performance in classroom He as to guide the teachers for the improvement of their teaching. In order to determine the areas equiring guidance, two questionnaires (3 & 4) are given These questionnaires should be used nly to find the areas where teachers require some help and not to pass any judgement on them y the supervisor

QUESTIONNAIRE 3

Teacher's Self-Evaluation

		Yes	Not quite	No
A Preparation				
1	Do I go through my lesson carefully before going to class?			
2	Do I prepare my teaching materials in advance?			
3	Do I set my objectives before starting to plan what activities are to be carried out?			
4	Do I plan my lesson in such a way that it fits the level of understanding of the students?			
5	Do I try the experimental activities myself before giving them to students?			
6	Is my lesson plan always ready for check up in case my supervisor wants it?			
B Instructional Skills				
1	Do I motivate my student's interest before starting a lesson?			

		Yes	Not quite	No
2	Do I ask questions to find out the pre-requisite knowledge of my students?			
3	Do I encourage my students to ask questions?			
4	Are my questions well formulated and understood by the students?			
5	Do I rephrase or simplify my questions for the benefit of slow students?			
6	Do I give enough time for my students to ask and answer questions?			
7	Do I give my students opportunity to carry out activities?			
8	Do I evaluate my students' understnading at the end of the lesson?			
9	Do I show equal attention to all my students?			
10	Do I praise students or answer well?			
11	Do the tests I give reflect the attainment of the objectives set for the lesson?			
12	Do I check the tests of my students carefully?			
13	Do I use the results of the tests as basis for further clarification if needed?			
14	Are the assignments I give properly motivated?			
15	Are the assignments challenging?			
16	Do I check the assignments of my students?			
17	Have I attended to those who did not do or complete their assignments?			

QUESTIONNAIRE 4

Supervisor's Evaluation on the Performance of Teachers

		Yes	Not quite	No
I Lesson Plan				
1	Are the objectives clearly stated?			
2	Are the experimental activities provided appropriate?			

		Yes	Not quite	No
5	Are there adequate questions to evaluate students' understanding?			
6	Does the evaluation provided reflect the objectives?			
2	*Instructional Skills*			
	(A) Introduction and Presentation			
1	Did the class start promptly?			
2	Was the interest of the students aroused before the lesson was introduced?			
3	Was the lesson systematically presented?			
4	Was the topic presented at the level of understanding of the students?			
5	Were the needed materials/apparatus ready?			
6	Did the teacher provide adequate experimental activities?			
7	Did the teacher ask proper questions to arrive at the conclusions?			
	(B) Teaching Techniques			
1	Were teaching aids utilized?			
2	Were the teacher's lead questions precise and concise?			
3	Did the teacher encourage students to ask questions?			
4	Did the teacher encourage students to look for the answers themselves?			
5	Did the teacher handle students' answers (correct or incorrect) well?			
6	Was the teacher able to motivate and perpetuate the discussion with more stimulating questions?			
7	Did the teacher lead the students to interpret their findings?			
8	Did the teachers show mastery of subject matter?			
9	Did the teacher teach the right concepts?			
	(C) Assignment and Evaluation			
1	Was the teacher able to evaluate the students' understanding at the end of the lesson?			
2	Were the objectives achieved as planned?			
3	Were the assignments motivating?			

		Yes	Not quite	No
4	Was the assignment challenging?	___	___	___
5	Were the data notebooks/workbooks of students checked regularly by the teacher?			

To score the Teacher's self evaluation and the Supervisor Evaluation on the performance of Teachers, the following simple procedure can be adopted:

> Question with YES answers are given a score of 2, NOT QUITE is given a score of 1, and NO answers a score of 0 The higher the total number of points the better is the performance of the teacher in the classroom

The comments would serve as a basis of suggestions to the teacher observed

CHAPTER 7

The Management of Science Education

he transaction of the science curriculum from curriculum developers to the students involves a umber of functionaries at the State, district and taluka levels. At these levels, the functionaries ivolved are the educational administrators namely, the Director of Education, the Joint Director, he Deputy Director, the Assistant Director, the Education Officers, the District Education Officers, he School Inspectors, etc. They are also involved in the management of supervision and inspection n the schools.

n a particular school, the Principal is the overall in-charge of both the academic and the dministrative functions. He manages these activities with the cooperation of the teachers, the udents and the community. All the States functionaries play an extremely important role in nproving the quality of science education by providing leadership in various fields, starting from urriculum development and going up to its effective transaction to the student level. The set-up f educational administrators in a few States and their functions are given at the end of this chapter.

1 Inspection and Supervision

nspection and supervision are often confused and treated as synonymous. Supervision is a ntinuous process undertaken to encourage and direct self-activated growth and a specialized elp to teachers for improving instruction.

he ultimate aim is, of course, improvement of science instruction. Inspection is done periodically nd includes an element of supervision. In most of the States, supervision and inspection are done y the same staff.

ith the formulation of the NPE-1986, the concept of supervision of science teaching has become ery important. The supervisors are now expected to play an important role by helping and guiding e teachers to solve their problems in teaching and in improving the quality of education. The upervising officer should visit the schools to guide and help in improving the school programmes nstead of only passing judgements. Supervision is regarded as a cooperative endeavour in which l the teachers participate, and the supervisor acts as a leader. He acts as a guide and consultant all educational matters. He helps in the organization of study groups, encourages professional reading and supports other form of in-service training. He encourages experimental work of various kinds and spreads amongst the teachers ideas useful to the achievement of this aim. A teacher should not distrust or fear the supervisor and carry the impression that his shortcomings will be reported to the school administrators. The supervisor should at the same time be careful that the teachers do not develop a feeling that they are more capable than the supervisor or that he has nothing of value to offer them. This attitude can be countered only by his efforts in acquiring the latest knowledge and a self-assessment of his academic growth at regular intervals.

7.1.1 Some Important Aspects of the Supervision and Inspection of Schools

The following aspects of supervision and inspection may be considered while inspecting the schools:

(a) School Building and Equipment
(b) School Staff
(c) School Funds
(d) Curriculum Materials
(e) Teaching-learning of Science
(f) Co-curricular Activities

(a) School Building

In addition to various facilities, the school building should have adequate space facilities for science teaching, carrying out science experiments/activities and for co-curricular science activities. The building should have classrooms, science laboratories or science rooms. The science laboratories/science rooms should be properly designed for maximum utilization. These should have the facilities of electricity and water, and a proper drainage system. There should be separate corner for repairing and improvising science equipments.

(b) School Staff

The science staff employed in a school should possess the requisite academic and professional qualifications. A science supervisor or inspector should persuade science teachers to use all curriculum materials and teaching aids and also organize co-curricular science activities.

(c) School Funds

Adequate funds should be allocated for the science teaching programme in the school. The funds should be properly utilized for purchase of equipments, apparatus and chemicals. For this, a list of various items of equipment, specifications of equipment and chemicals, sources from where these can be purchased, books, etc., may be provided to schools. Funds should also be made available for maintenance of the various items of equipment and for their replacement and repairing. Some funds should be provided for purchase of science books for the library, organizing l trips, and co curricular science activities such as debates on current science topics, science ubs, science exhibition, science essay competition, science assembly, etc.

) *Curricular Materials*

ie curricular materials for the Upper Primary and Secondary stages consist of textbooks, acher's handbooks, workbooks, etc. There is a kit for the Upper Primary stage for carrying out tivities. In addition to this, teachers can also use certain audio-visual aids such as certain mstrips and films available in NCERT and from other agencies.

) *Teaching-Learning of Science*

ie curricular materials in the class should be used for achieving the objectives of science teaching entioned in the NPE-1986. The methods and techniques used in the classroom for teaching ould encourage an active participation of the pupils in the teaching-learning process. The pupils ould take the initiative in acquiring new knowledge in science, and should develop the habit of lf-study. The demonstrations and pupils' activities should be properly organized. The teaching ds such as charts and models should be suitably used. Improvisation of simple apparatus and nstruction of models should be encouraged. Proper procedures should be used for the formative d summative evaluation of pupils' progress.

Co-curricular Activities

-curricular activities supplement the knowledge gained by pupils in the classroom and help em to utilize their leisure fruitfully.

me of the co-curricular activities are: reading supplementary reading materials, such as popular ience articles and popular science magazines, carrying out science activities at home/in school, rticipation in science fairs and exhibitions, working in the science club, etc.

ie student may also carry out small investigations. These provide a chance to pupils to carry out ientific investigations, plan the work, think of various ways to carry out the investigation and erpret the data.

ie supervisors should provide adequate guidance to teachers in organizing such activities. The achers should see that every student participates in one or more co-curricular activities.

7.1.2 Supervision of Science Teaching

ie supervision of science teaching in schools assumes greater importance in view of the renewed nphasis on science teaching for first ten years of school education. The supervision is not nfined to only the administrative role of supervisory staff. It is concerned mainly with providing idance facilities to the science teachers.

Supervision is an expert professional service and is concerned with the improvement in learning science. It is concerned with the long-range improvement of science education. A science supervisor provides effective leadership to science teachers and is directly concerned with their academic growth. The following are the main important functions of a science supervisor:

1. He should be well acquainted with the science curriculum of his State/district. For this, it is necessary that he participates in the programmes concerning science education. (Curriculum development, teacher-training, etc.).
2. He should organize teacher-training programmes for updating the knowledge of teachers of his State/district in content as well as methodology.
3. He should have a proper mechanism to check the quality of chemicals, apparatus, biology specimens and equipment purchased by the school.
4. He should design programmes for both (a) talented students, so as to provide them opportunities to learn at their own pace, and (b) weaker students so as to provide them extra assistance in learning.
5. He should evaluate instruction by direct classroom visits and individual conferences with teachers.
6. He should occasionally check the lesson plans of teachers and suggest improvements.
7. He must emphasize showing appropriate demonstrations and encouraging student participation in the learning process. Sometimes model lessons may be given to teachers to acquaint them with the methods suitable for that particular section of pupils.
8. He should see that adequate funds are available for the science teaching programme in schools. This includes the setting up and maintenance of laboratories and science rooms, purchase of common material for student's science activities; field trips, such as collection of samples, visits to factories for a first-hand experience of work and to other places of scientific importance.
9. He should encourage teachers to undertake small action research programmes.
10. He should insist on the use of local resources for science teaching and designing low-cost science apparatus.
11. He should organize joint and common school science activities (science exhibitions, debates, etc.) for the cluster of schools under his jurisdiction.
12. While visiting the schools, a supervisor should keep all the relevant papers (copies of letters issued regarding sanction of funds, and other instructions issued, lists of specifications, etc.,) with him.
13. A supervisor should maintain a diary in which he may note down the suggestions given and follow-up actions taken on his next visit.

In order to effectively discharge his role, a science supervisor should have a thorough subject background and be in touch with the recent developments both in science and science education. A science supervisor should possess all the qualities of a good teacher so that he/she may act as a cilitator in addition to being a supervisor He should maintain good relations with teachers He ust have the quality of leadership He should also possess a sense of humour and the maturity to cept arguments against those he has given

7.1.3 Suggested Outlines for a Programme for Supervising Staff

three days orientation programme is suggested for science supervisors at the district level in ties It is expected that after undergoing orientation, a science supervisor will be able to do a ore effective supervision

rst Day

(a) Familiarization with the NPE 1986 in the context of science education
(b) Objectives of science teaching and aims of general education
(c) Philosophy of the new science courses followed by States
(d) General methods for science teaching
(e) Organization of teacher-training programmes

cond Day

(a) Acquaintance with places of scientific interest in the State/district
(b) Financial requirements and estimates in maintaining laboratory equipment, and chemicals, and other activities
(c) Familiarity with laboratory equipment in the various science disciplines, and their specifications
(d) Knowledge of suppliers of scientific equipment of good quality, purchase procedure, etc

ird Day

(a) Designing programmes for talented and weaker students.
(b) Spot evaluation, methodology of evaluation in various disciplines
(c) Knowledge of various action research programmes
(d) Co-curricular activities like conducting inter-school science debates, quizzes, exhibitions, etc.

ganization of Conferences/Seminars/In service achers' Training

nferences/Seminars for teachers, Headmasters and Principals are very important for exchange ideas and for updating the knowledge The Conference may be organized periodically or at least ce in a year to discuss: (a) the various problems faced by the schools in respect of science ching, and (b) any current topic of content or methodology pertaining to science

The State authorities may organize periodically the in- service training programmes of teachers for improvement of science education

7.2 Role of Principals in Management of Science Education in Schools

The Principal, being the Head of the Institution, plays a very important role in finding the ways and means of imparting science education in his institution

The following are some suggestions for Principals for implementation of science teaching programmes in schools in accordance with the National Policy on Education – 1986·

1 Coordination

The coordination of various science activities in the school is an important task of the school The Principal may assign this task to some senior science teacher He/she will draw up programmes concerning science education in consultation with the science teachers and with the Principal of the school. He/she also keeps the Principal informed about the requirement of the science department

2 Supervision

This consists of supervision of classroom teaching, programme of evaluation, and co-curricular activities Supervision of classroom teaching is an important duty of the Principal He should regularly visit the classes being taught by the different teachers The Principal should avoid giving suggestions to the teachers in the presence of students He may suggest improvements in a pleasant and friendly manner after the class. He should encourage the teachers to carry out investigations, demonstration- experiments and action researches for the improvement of science teaching If the Principal happens to be a person with a non-science background, he may take the help of other science teachers in the supervision work.

The Principal may invite old students of the school, parents or educated persons from the community, who have interest in science teaching, to help science teachers in their work. He may also take the help from voluntary organisations, local scientific institutions, etc

3 Science Based Co-curricular Activities

The Principal should assign the organisation of various co- curricular activities to teachers keeping in view the interest for a particular activity. A proper place should be provided in the time table for carrying out these activities. He should encourage teachers and students to participate in co-curricular activities

The following science based co-curricular activities are suggested for being taken up in the schools *(a) Science Club Activities*

- (i) *Science Seminars* The students and teachers may participate in the seminar. The guest speaker may be invited to deliver a talk on any topic of current importance concerning science
- (ii) Field trips to places of scientific importance, industrial units, scientific institutions
- (iii) Competitions may be organized in writing science articles and collection of good articles may be given the shape of a magazine
- (iv) Scientific hobbies like electronic circuits, photography, etc. may be pursued.

(b) Science Exhibition

The conduct of science exhibition in the school and to encourage the children to participate in science exhibitions conducted at District/State/National levels.

(c) Celebration of Science Festivals

Science festivals may be celebrated on the following days

28 Febuary	National Science Day (The birthday of Dr. C.V Raman)
5 June	National Environment Day

The suggested activities to be undertaken on these days include

- (i) Depicting life of scientists, conducting seminars, quiz, writing competitions, important aspects in morning assembly
- (ii) Distribution of prizes for various competitions conducted during the year
- (iii) The above given dates (Feb. 28, June 5) are only two specific activities. The birthdays of other scientists may be celebrated at least during the morning assembly

Funds may be allocated for the organization of co-curricular science activities and also for purchase of popular science journals of school level

(d) Other Activities

The following activities may also be undertaken

- (i) Putting up photographs of great scientists on the walls of the laboratory and the classrooms
- (ii) Preparing and putting up charts showing some experiments,

(iii) *Science Film Shows*: Teachers may be encouraged to get science films from film libraries and show them to students

(iv) *Science Corner/Library Museum* Students should be given a separate room/place where they may read science magazines, periodicals and display specimen prepared by them. Adequate number of periodicals and reference books should be made available

4 *Timetable Framing*

(i) The timetable should be arranged in such a way that science teachers get preparation periods to make arrangements for demonstration and laboratory work.

(ii) Provision may be made in the timetable so that students may listen to Radio Science lessons or watch lessons on television

5 *Laboratory Equipment*

The science laboratories should be well equipped The Principals should convince the concerned authorities regarding the needs of the science laboratories of his institution The teachers may be encouraged to improvise low-cost material (wherever possible)

The Principal may see to it that the laboratories are properly maintained and the facilities available are fully utilised

6 *Provision of Funds and Purchase of Materials for Science Activities*

Provision may be made for contingent grant for purchase of science materials, such as chemicals, science specimens and teaching aids (such as models and charts) The Principal may also get science kits for his institution

Several types of grants are provided by the concerned authorities to the school The practice of making purchases at the end of the financial year should be avoided The Principal may appoint a purchase committee for the purchase of science equipment apparatus and chemicals

The administrative set-up of a few states and their broad functions are given in the ensuing pages

FUNCTIONS OF EDUCATIONAL ADMINISTRATORS/OFFICERS OF ANDHRA PRADESH

S. No.	*Designation*	*Functions*
1	Director of School Education	Ex-Officio Commissioner of Government Examinations
2	Joint Director	In charge of all educational institutions in the State
3	Deputy Director	Issues recognition to English-medium schools
4	Assistant Director	Inspection and supervision through District Education Officer
5	Regional Director (one for 3 to 4 Districts)	Issues recognition to Telugu-medium schools, inspection and supervision through District Education Officer
6	District Education Officer	Inspection and supervision of schools in District, issues recognition to Primary and Upper Primary schools
7	Deputy Education Officer (one for each 5 to 6 Zones in a District)	Inspection and supervision of high schools
8	Inspector of Schools	Inspection of Primary and Upper Primary schools
9	Deputy Inspector of schools	To assist the District Education Officer

11 DDE (Textbooks)

He/she is ex-officio Director of the Delhi Textbook Bureau His/her office is responsible for adapting any textbook and for transportation of NCERT books, printing of books and production and distribution of textbooks

12 D D E (Districts)

The Union Territory of Delhi is at present divided into five educational Districts each being headed by a D D E Each District has a certain number of zones as follows

(i) District — North – Comprises Zones 1 to 7
(ii) District — East – Comprises Zones 8 to 11
(iii) District — Central – Comprises Zones 12 to 16
(iv) District — South – Comprises Zones 17 to 22
(v) District — West – Comprises Zones 23 to 28

13 Zonal Education Officer

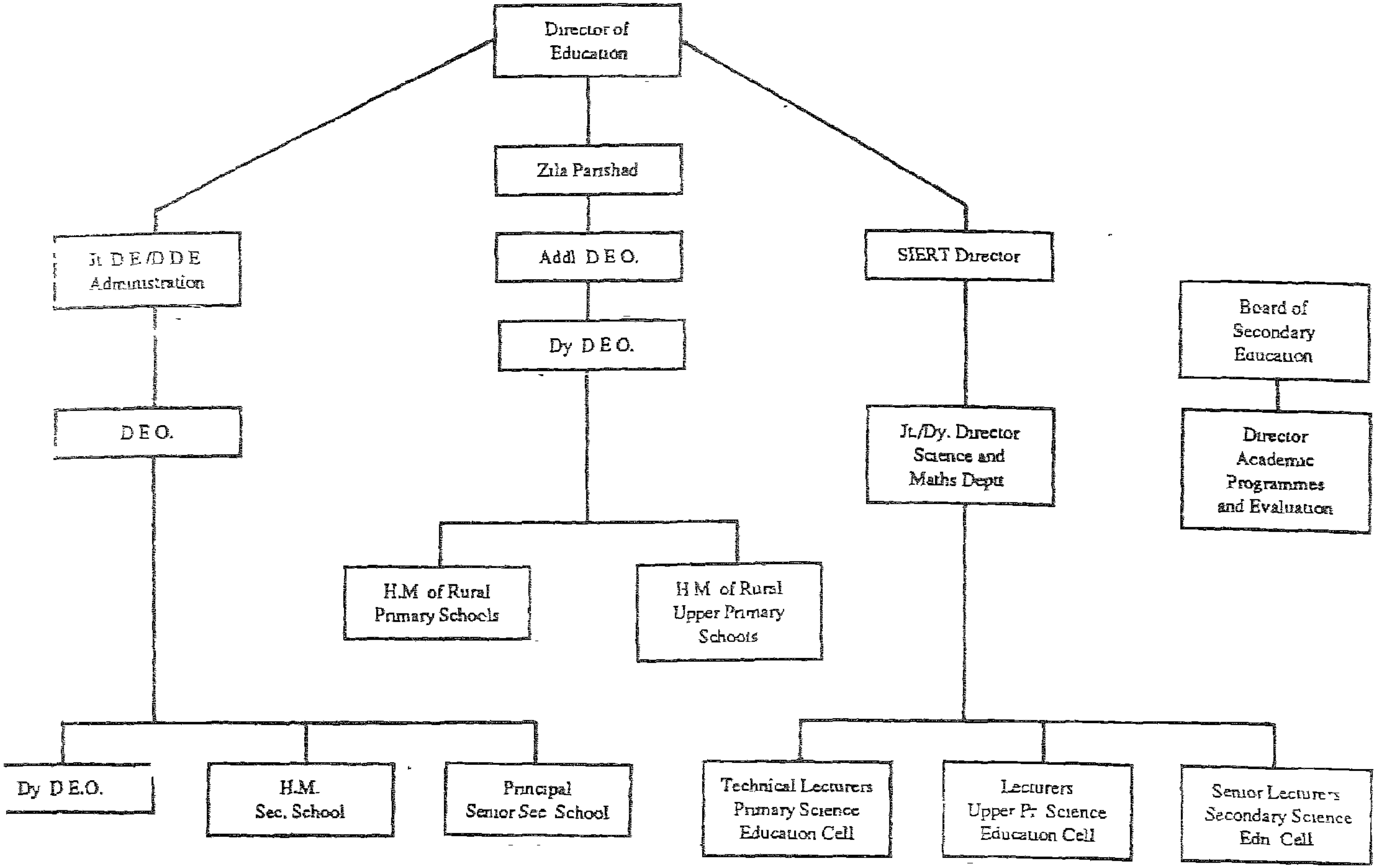
Each zone is headed by one Education Officer (E O) and there is a Dy Education Officer (D.E O) On an average each zone has 30 to 40 schools of all types (Middle/Secondary/Sr Secondary/Boys/Girls/Co educational/Govt /Aided/Unaided The D D E (Districts) is the head of the District and deals with administrative or academic matters through the respective E O and D E Os.

Hence, the Heads of all schools are under the concerned Zonal Education Officers

Deputy Director of Education (Science)

The D D E (Sc) deals with any or all matters related to science education, vocational education and work education (SUPW) programmes, at the different science centres under him/her

DIRECTORATE OF EDUCATION, RAJASTHAN


Director of Education
Jt DE/DDE Administration
D E O.
Dy D E.O.
H.M. Sec. School
Principal Senior Sec School
Zila Parishad
Addl D E O.
Dy D E O.
H.M of Rural Primary Schools
H M of Rural Upper Primary Schools
SIERT Director
Jt./Dy. Director Science and Maths Deptt
Technical Lecturers Primary Science Education Cell
Lecturers Upper Pr Science Education Cell
Senior Lecturers Secondary Science Edn Cell
Board of Secondary Education
Director Academic Programmes and Evaluation

FUNCTIONS OF DIFFERENT EDUCATIONAL ADMINISTRATORS/OFFICERS OF RAJASTHAN

S No	*Designation*	*Functions*
1	Director of Education	Administrative and academic head of the education department of Rajasthan
2	Director (Board of Secondary Education)	Evaluation work and academic programmes
3	Director (SCERT)	Provides academic guidance, conducts teacher training programmes and also supervision work in schools
4	Joint/Deputy Director (SCERT)	Academic guidance, teacher training, supervision of curriculum development and educational research at the departmental level
5.	Joint Director of Education (Administration)	Overall administration and supervision
6.	District Education Officer	Overall administration and supervision at the district level
7	Principal	Administrative and academic head of a Senior Secondary School
8	Headmaster	Administrative and academic head of a Secondary School

FUNCTIONS OF DIFFERENT EDUCATIONAL ADMINISTRATORS/OFFICERS OF TAMIL NADU

S No	Designation	Functions
1	Director of Education	Academic and Administrative Head in the State
2	Additional Director	Overall responsibility for education from Primary to Senior Secondary Levels
3	Joint Director	"
4	Deputy Director	"
5	Chief Education Officer	Inspection and supervision of schools in more than one District
6	District Education Officer	Inspection and supervision of schools in one District
7	Deputy Inspector of Schools (more than one in each District)	Supervision and inspection of schools in his/her part of the District
8	Chief Inspector (only one in the State)	Looks after the education of girls in the State

APPENDIX I

A Workshop on Development of Guidelines on the Teaching of Science for Different Levels of Education Functionaries of States

VENUE DESM, NIE–NCERT, New Delhi
DURATION 16–17 September 1987

List of Participants

Name	Address
Professor J G Bhogale	State Institute of Science Education, Ravinagar, Nagpur, Maharashtra
Shri S B Dhobi	Head, Science Unit, State Institute of Education, Ahmedabad, Gujarat
Shri R K Pathania	State Council of Educational Research and Training, Solan, Himachal Pradesh
Shri P N Seth	Education Officer, Central Board of Secondary Education, 2/42, Sant Vihar, Ansari Road, Daryaganj, New Delhi 110002
Shri B N Talukdar	Reader, State Institute of Science Education, Assam, Guwahati-20
Ms Sharada, A S	Gazetted Lecturer, SIS–DSERT, Basavangudi, Bangalore-4
Shri S N Nigam	Director, State Institute of Science Education, Jabalpur, Madhya Pradesh
Shri N C Sharma	Professor of Physics, State Institute of Science Education, Allahabad, Uttar Pradesh
Professor R D Shukla	DESM–NCERT, Sri Aurobindo Marg, New Delhi 110016
Dr K B Gupta	DESM–NCERT, Sri Aurobindo Marg, New Delhi 110016
Dr Brahm Prakash (Programme Coordinator)	DESM–NCERT, Sri Aurobindo Marg, New Delhi 110016

APPENDIX II

A Workshop on Development of Guidelines on the Teaching of Science for Different Levels of Education Functionaries of States

VENUE Physics Department, Osmania University, Hyderabad 500 007

DURATION 7–12 January 1988

List of Participating Members

	Name	Address
1	Dr Ramesh Chandra Tewari	Head of the Chemistry Department, Delhi Public School, Mathura Road, New Delhi
2.	Dr D K Mukhopadhyay	Lecturer in Education (Life Science), Vinay Bhavan, P O Santiniketan, District Birbhum 731235, West Bengal
3	Mrs R Saradha Rani	Lecturer, Andhra Mahila Sabha, College of Education, Hyderabad-7
4.	Smt R S David	Lecturer, Andhra Mahila Sabha, College of Education, Hyderabad-7
5	Mrs Kalindi Bhatnagar	Lecturer in Zoology, RBVRR College, Narayanguda, Hyderabad-29
6	Dr. Sulochana Mathur	Principal, SN Vanita Mahavidyalaya, Exhibition Ground, Hyderabad 500001
7	Mrs Mehrunissa	Head, Department of Chemistry, SN Vanita Mahavidyalaya, Exhibition Ground, Hyderabad 500001
8	Shri K V Rao	Principal, Kendriya Vidyalaya, Shivarampally, Hyderabad 500252
9	Shri V M Arya	Lecturer, School of Science Education, SCERT, 3 Link Road, Karol Bagh, New Delhi
10	Dr K.K Tiwari	Professor of Chemistry, State Institute of Science Education, Jabalpur, Madhya Pradesh
11	Dr G Raju	Professor of Zoology, Regional College of Education, Mysore 570006
12	Dr C.V Bhardwaj	Head, Department of Physics, SCERT, 3 Link Road, Karol Bagh, New Delhi
13	Mrs Seethamani	PGT, Kendriya Vidyalaya, Picket, Secunderabad 500003
14	Dr Saraswathi Balasubramaniam	Lecturer, NSR College of Education, VV Campus, Jambagh, Hyderabad
15	Dr G Srinivasacharyulu	Lecturer, NSR College of Education, VV Campus, Jambagh, Hyderabad

	Name	Address
16	Dr V.B. Kamble	Scientist, Vikram A. Sarabhai Community Science Centre, Navarangapura, Ahmedabad 380009
17	Professor K. Rama Reddy (Honorary Director)	Professor of Physics, Department of Physics, Osmania University, Hyderabad 500007
18	Professor R.D. Shukla	DESM-NCERT, Sri Aurobindo Marg, New Delhi 110016
19.	Dr Brahm Prakash (Programme Coordinator)	DESM-NCERT, Sri Aurobindo Marg, New Delhi 110016